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Cornell University Remote Sensing Program

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Principal Investigator: Ta Liang

Co-Investigator: Warren R. Philipson

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June 9, 1980

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Subject: NASA Grant NGL 33-010-171

Gentlemen:

In accordance with the provisions of the subject grant, we are transmitting herewith two (2) copies of our 16th Semi-Annual Status Report, covering the period December 1, 1979 to May 31, 1980. In addition, three (3) copies of this report are being sent directly to the Technology Transfer Division, NASA Headquarters, Washington, D.C. 20546 (Attention: Mr. J.A. Vitale).

Sincerely yours,

Ta Liang

Ta Liang
Principal Investigator

TL/pw

cc: Mr. J.A. Vitale, NASA Headquarters
Mr. D.A. Douvarjo, NASA Headquarters
Deans T.E. Everhart and P.R. McIsaac
Mr. T.R. Rogers and Mr. F.J. Feocco
Director R.N. White

## INTRODUCTION

The primary objective of the NASA-sponsored, Cornell University Remote Sensing Program is to promote the application of aircraft and satellite remote sensing, particularly, in New York State. In accordance with NASA guidelines, this is accomplished through conferences, seminars, instruction, newsletters, news releases, and most directly, through applied research projects. Each project must be, in some way, unique; essentially noncompetitive with commercial firms; and potentially, benefit- or action-producing. Relatively little emphasis is placed on technology transfer, per se.

The activities of the Remote Sensing Program staff, from December 1, 1979 to May 31, 1980, are reviewed in this Semi-Annual Status Report, the sixteenth to be submitted to NASA since the Program's inception in June 1972.

## COMMUNICATION AND INSTRUCTION

### Contacts and Cooperators

One vital element to the success of Cornell's Remote Sensing Program is communication. The Program staff spends many hours discussing remote sensing with representatives of various federal, state, regional, county and local agencies, public and private organizations, the academic community and foreign countries.

Over the past six months, members of the Program staff presented a research paper on remote sensing for vineyard management at the 46th Annual Meeting of the American Society of Photogrammetry, in St. Louis (Appendix C). At the request of officials of the N.Y.S. Department of Health, Program staff travelled to Albany, N.Y., to present a special workshop on remote sensing of the Love Canal landfill for State personnel of the Department of Health and the Attorney General's office. Staff members also visited with representatives of the N.Y.S. Energy Office, in Albany, to confer on possible cooperative projects.

In addition to hosting remote sensing seminar speakers from five U.S. and one Canadian government agencies, three private industries, one research institute, and the United Nations (Appendix E), Program staff received visitors from Chile, China, Italy and Tanzania, as well as project cooperators from the N.Y.S. Office of Parks and Recreation, the N.Y.S. College of Environmental Science and Forestry at Syracuse, and several other Cornell departments.

As in the past, many new and continuing dialogs were also held via the mail and telephone (Appendix D). These were often in response to requests for remote sensing consultation (e.g., Eastman Kodak regularly refers requests for advice on remote sensing applications to the Program); but several were of value in developing new remote sensing projects.

## Newsletters

The Program's "Cornell Remote Sensing Newsletter" continues to serve as an important link to and beyond the Cornell community (Appendix G). By highlighting remote sensing activities at Cornell while reporting other items of interest, the Newsletter has attracted a readership which greatly exceeds the mailing list of more than 550 individuals or groups in over 40 states and 20 countries (Appendix F).

## Seminars

As noted, the Program's weekly Seminar in Remote Sensing, a one-credit hour course in the School of Civil and Environmental Engineering, returned for the spring semester. In bringing experts from government, industry and other institutions to Cornell to discuss a wide range of remote sensing topics, the Seminar attracted audiences of from 55 to 70, with a course registration of 32 graduate and 21 undergraduate students from some 15 Cornell divisions (Appendix E).

## Courses, Special Studies and Workshops

Over the past six months, Program staff worked to streamline and reorient Cornell's longstanding curriculum in Aerial Photographic Studies and Remote Sensing. The 1980-81 course offerings will reflect even greater emphasis on remote sensing technology which is syncnomous with NASA (Appendix E). Notably, three of the six formal courses in the revised curriculum were developed under the NASA grant, and one other new course on digital image analysis is currently being planned.

Although the formal course offerings will change, the possibilities for research through special topics courses, professional master's design projects, and M.S. or Ph.D. theses will remain the same. For example, during the spring semester, 1980, some 125 students were enrolled in formal courses in this area, and ongoing graduate thesis investigations included: Remote sensing for engineering properties of arid region landforms (Ph.D., William L. Teng); Development of a remote sensing methodology for rangeland monitoring in Botswana (M.S., Elaine S. Aderhold); A comparative study of small scale remotely sensed data for monitoring clearcutting in hardwood forests (M.S., William R. Hafker); and Assessment of potential industrial sites in Essex County, N.Y. (M.E.Civil, Thomas M. Wozny). The latter two studies have received direct financial support from the NASA grant. (Three other graduate students are in the early stages of defining thesis topics.)

Typical of the staff's extracurricular instructional activities over the past six months are a special remote sensing orientation lecture for some 60 Cornell students in a course in landscape architecture; and, as noted, a special workshop on the Program's remote sensing analysis of the Love Canal landfill for some 20 scientists and lawyers of the N.Y.S. Department of Health and the N.Y.S. Attorney General's Office.

## DATA AND FACILITIES

As described in earlier reports, staff research and instruction have been enhanced through continued acquisition of a wide range of remotely sensed, aircraft and satellite data, and through extension of capabilities for their analysis and interpretation. These data, along with Program facilities and equipment, are made available at no cost to cooperators, students and other interested users.

With assistance from the NASA Office of University Affairs, the Program has received Landsat, Skylab, high altitude and low altitude coverage of sites in the Northeast, and one new aircraft multispectral scanner mission is scheduled for the summer 1980. The U.S. Environmental Protection Agency has also overflown Program-selected sites at no cost to the Program; and imageries have been obtained from the U.S.A.F. Rome Air Development Center, the U.S. Geological Survey, the U.S. Department of Agriculture, the St. Lawrence Seaway Development Corporation, the National Air Photo Library of Canada, the Tri-State Regional Planning Commission, the National Archives, Eastman Kodak Company and several commercial mapping firms. In addition, the NASA Johnson Space Center recently suppied the Program with copies of selected surplus films.

The Program maintains or has access to spectroradiometers and selected image analysis equipment (i.e., zoom and non-zoom stereoscopes, density slicer, color-additive viewer, Zoom Transfer Scope, densitometer, steroplotters, and other photogrammetric and photographic instruments). A Stereo Zoom Transfer Scope was also recently purchased, in part, with NASA grant funds.

The Program has an active file of computer routines for analyzing multispectral digital data. These routines have received increased usage in Program-sponsored, spinoff and thesis investigations with Landsat and aircraft scanner data. Additionally, the Program's computer routines for analyzing Landsat tapes are now being used by researchers at the N.Y.S. College of Environmental Science and Forestry, and the State University of New York at Binghamton, the latter, via a telephone link.

## PROJECTS COMPLETED

During the six month period, December 1, 1979 to May 31, 1980, the Cornell Remote Sensing Program staff completed two applied research projects: (1) Assessment of the Value of Landsat for Extending Snow Records, and (2) Airphoto Inventory of Abandoned Oil Wells in Allegany State Park, N.Y. The projects are summarized here, and project reports are included in an appendix.

1. *Assessment of the Value of Landsat for Extending Snow Records*

This study was initiated to better define the temporal and spatial distribution of snow in New York, for the N.Y.S. Office of Parks and Recreation. Toward this same objective, the study became an investigation of improved methods for extending snow station measurement records (Appendix A). Although cloud-free Landsat data can provide an adequate picture of the spatial distribution of snow, there is no means for extrapolating this information beyond the dates of the images. To accomplish this task, the Program staff devised a simple approach which uses statistical correlations between the snow cover interpreted at any location in a Landsat scene and the snow depths measured at ground stations in the region. Using regression equations, it should be possible to estimate the occurrence of snow at any location, on any date for which snow station records exist. Consequently, it should be possible to extend the Landsat-derived record of snow occurrence over time.

2. *Airphoto Inventory of Abandoned Oil Wells in Allegany State Park, N.Y.*

At the request of the N.Y.S. Office of Parks and Recreation, the Program staff performed an airphoto inventory of abandoned oil wells in the 60,200 acre Allegany State Park (Appendix B). Using Park coverage which included photo indexes of 1939 panchromatic aerial photography as well as 1973 NASA high altitude color infrared photography, the Program staff found some 90 previously unidentified, abandoned wells. These will now be checked in the field by Park personnel. Confirmed wells will be re-drilled, filled and covered with a concrete cap in order to remove the potential safety hazard and the likely avenue for ground water contamination.

## PROJECTS IN PROGRESS

Program-Sponsored

As of June 1, 1980, the Cornell Remote Sensing Program staff was conducting five applied research projects and one assistance project under the NASA grant:

- applied research projects

  1. Assessment of Potential Industrial Sites
  2. Evaluation of Data Sources for Monitoring Hardwood Forest Clearcutting
  3. Site Selection for Wind Mills
  4. Feasibility Study for a Wood Power Plant
  5. Studies of Vineyard Management and Yield Estimation

- assistance project

  6. Remote Sensing Consultations Regarding the Love Canal Landfill

The objectives, cooperators, users, expected benefits and actions, and status of these projects are described, as follows:

1. *Assessment of Potential Industrial Sites*

| | |
|---|---|
| -cooperator/user: | Planning Office, Essex County, N.Y. |
| -benefits/action: | Identification of the most suitable industrial sites will be used in site planning and attracting industry |

-expected completion data: August 1980

In an attempt to improve its employment situation, Essex County, N.Y., is seeking to attract new industries. As part of its Economic Development Study, the County Planning Office must identify suitable industrial sites. The Program was requested to assist this effort. In response, one student has taken on the study as a Master of Engineering design project.

The analysis of high and medium altitude aircraft photographs and supporting information on the 4,730 sq. km. (1,825 sq. mile) county is nearing completion. Factors being evaluated include land availability, slope, site accessibility, soil drainage, other subsurface characteristics, and the expected physical as well as visual impacts on existing land use. To date, areas unavailable or unsuitable for development have been eliminated, and the remaining areas are being assessed to arrive at the best sites.

2. *Evaluation of Data Sources for Monitoring Hardwood Forest Clearcutting*

| | |
|---|---|
| -cooperators: | N.Y.S. Adirondack Park Agency; U.S. Forest Service (Alleghany National Forest, Pennsylvania) |
| -user: | N.Y.S. Adirondack Park Agency |
| -benefits/actions: | The adoption of remote sensing methods for monitoring forest cutting in the Adirondack Park |

-expected completion date: August 1980

The N.Y.S. Adirondack Park Agency requested that the Program assess the utility of Landsat satellite data for identifying and monitoring clearcutting in the Park. In response, one student has undertaken a Master of Science thesis research project to study the comparative utility of remotely sensed imagery of various scales, seasons and spectral sensitivities, for identifying clearcutting in hardwood forests.

When no suitable study area could be found in the Adirondack Park (primarily, for lack of documented clearcuts), the focus of the research was shifted to the Allegheny National Forest, in northwestern Pennsylvania. Here, visual and digital analyses of satellite and high altitude aircraft data have been completed, and final interpretations are beginning. Overall, the information should be transferable to the Adirondack Park and be applicable in developing a monitoring capability.

3. *Site Selection for Wind Mills*

-cooperator: N.Y.S. Energy Office

-user: N.Y.S. Energy Office; citizens of New York

-benefits/actions: Selection of best sites for anemometers and, if viable, wind mills

-expected completion date: 1st phase--September 1980

At the request of the N.Y.S. Energy Office, members of the Program staff have begun a study to develop and test a site selection methodology for wind mills. Using remotely sensed and other data, the staff will select several sites for anemometers in western New York, with erection scheduled for late summer 1980. As planned, the methodology would then be refined and tested in other areas.

4. *Feasibility Study for a Wood Power Plant*

-cooperator: N.Y.S. Energy Office

-users: N.Y.S. Energy Office; citizens of Tupper Lake, N.Y.

-benefits/actions: If viable, development of wood power plant, with reduced usage of non-renewable fuel sources

-expected completion data: December 1980

At the request of the N.Y.S. Energy Office, members of the Program staff have begun a study to assess the feasibility of developing a ten megawatt, wood-burning power plant in the vicinity of Tupper Lake, in the Adirondack Mountains of New York. Toward this end, land within a 50km (30 mile) radius of Tupper Lake is being surveyed for its availability, accessibility and forest cover using remotely sensed and other data. If it is determined that adequate supplies of wood can be tapped from this area with minimal adverse environmental impact, the power plant will be developed with State funding.

5. *Studies of Vineyard Management and Yield Estimation*

-cooperator/user: Taylor Wine Company; N.Y.S. Agricultural Experiment Station

-users: Taylor Wine Company & other vineyards; USDA Economics, Statistics & Cooperatives Service

-benefits: Potentially, the capacity to improve and estimate vineyard yield with remotely sensed data

-expected completion date: June 1981

As a follow-up to previous vineyard-related investigations (7th, 9th and 14th Semi-Annual Status Reports, Dec 1975, Dec 1976 and June 1979), the Program staff is attempting to develop an algorithm for predicting vineyard yield on the basis of remotely sensed measurements (Appendix C). Photographic and multispectral scanner data acquired for the Program by NASA in 1977 are being re-evaluated; a comprehensive series of field spectroradiometric studies are planned for Cornell's experimental vineyard in Fredonia, N.Y., as well as for Taylor Wine vineyards in Hammondsport, N.Y., throughout the summer and early fall of 1980; and NASA/JSC has scheduled one aircraft multispectral scanner mission over the Fredonia and Taylor sites for August 1980.

6. *Remote Sensing Consultations Regarding the Love Canal Landfill*

| | |
|---|---|
| -cooperator: | N.Y.S. Dept. of Health |
| -users: | N.Y.S. Dept. of Health, N.Y.S. Dept. of Environmental Conservation, N.Y.S. Attorney General's Office, and U.S. Environmental Protection Agency |

-expected completion date: Present consultations--Sept. 1980

As a follow-up to the Program's earlier analysis of the Love Canal landfill in Niagara Falls, N.Y. (13th Semi-Annual Status Report, Dec 1978), the Director of the Toxicology Laboratory of the N.Y.S. Department of Health has periodically requested additional remote sensing interpretations and support. These continuing consultations regarding the Love Canal landfill are proceeding under the NASA grant.

## Spinoff Projects

During the past six months, the Program staff has been involved in two spinoff projects that arose directly from NASA-funded investigations. The first project is a remote sensing analysis of some 40 toxic waste landfills in the Niagara Falls area of New York. Partially supported by the N.Y.S. Department of Health, this work follows the Program's assessment of Love Canal (13th Semi-Annual Status Report, Dec 1978), as well as earlier leachate detection studies which were funded jointly by NASA and EPA.

Similarly, in an effort to extend the findings of a NASA-funded study of river flooding (14th Semi-Annual Status Report, June 1979), the Program sought and received a research grant to investigate flood modeling with Landsat. This 12-month study began in October 1979 and is being funded by the Office of Water Research and Technology, U.S.D.I. The Program has also received tentative approval for a second grant from the OWRT to develop a remote sensing methodology for improving lake sampling strategies. This latter study would begin in October 1980.

## FUTURE PROJECTS

The Program staff is continually soliciting and receiving proposals for new remote sensing, applied research projects (Appendix D). As described, criteria for project acceptance are that the project must be, in some way, unique; that project acceptance would not compete unduly with private companies or consultants; and that, if completed successfully, the project would produce tangible benefits or actions by defined users.

Among the projects that are planned for initiation during the next few weeks are:

1. With the *Boyce Thompson Plant Research Institute*--conduct field and laboratory spectroradiometric studies of controlled plantings to assess the spectral effects of (a) sulphur dioxide, (b) ozone and (c) acid rain.

2. With the *Boyce Thompson Plant Research Institute*--conduct greenhouse spectroradiometric studies to develop a remote sensing test for screening salt tolerance of tomatoes.

3. With the *Coastal Management Program, N.Y.S. Department of State*--develop a remote sensing methodology for inventorying coastal aesthetic resources that are located on, or visible from, public land.

4. With the *N.Y.S. Department of Commerce*--inventory the coniferous forests in New York's southern tier to assess the feasibility of developing a particle board manufacturing industry.

## PROGRAM STAFF

The Program staff is comprised of Prof. Ta Liang, principal investigator, Prof. Warren R. Philipson, co-investigator, Thomas L. Erb, research specialist, Chain-Chin Yen, computer data analyst, and Pat Webster, secretary. Profs. Donald J. Belcher and Arthur J. McNair, and Dr. Ernest E. Hardy are general consultants to the Program, and for specific projects, assistance has been provided by many Cornell and non-Cornell personnel. Students who have contributed significantly to the Program staff effort over the past six months include Lisa K. Balliett, William R. Hafker, Karen L. Jahn, Katherine A. Minden, and William L. Teng.

## LIST OF APPENDICES

# APPENDIX A

## Assessment of the Value of Landsat for Extending Snow Records

# EXTENDING SNOW RECORDS WITH LANDSAT

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## ABSTRACT

The spatial distribution of snow in two 625 sq. km. test areas in New York was interpreted from Landsat imagery and extended temporally through correlation with snow measurement station records. This technique might be used for estimating long-term snowfall conditions in areas without stations, as well as for evaluating the locations of existing or planned snow measurement stations.

## INTRODUCTION

The use of Landsat data for mapping snow has been demonstrated by various researchers (Barnes and Bowley, 1974; Wiesnet and McGinnis, 1974; Katibah, 1975; Thomas et al., 1978). Although limited by the frequency of imaging (9 or 18 days), or obscured by clouds, forest or mountain shadows, Landsat data are of substantial value for extending snow cover boundaries spatially, beyond snow measurement stations (Rango et al., 1975; Sharp and Thomas, 1975; Khorram, 1977; Rango et al., 1979).

For planning purposes, it would be of comparable value to be able to extend the Landsat-derived snow cover record temporally, between and before the dates of the Landsat images. The aim is to estimate

long-term snowfall conditions in unmonitored areas (i.e., areas without snow measurement stations). In this study, a technique was developed for accomplishing this objective.

The technique rests on the assumption that, because of the general regularity in air mass patterns, snowfall at nearly any location in a region is correlated with, and thus can be estimated by, the pattern of snowfall at weather stations in the region. Accordingly, the spatial distribution of snow determined from a Landsat image should be correlated with snow depths recorded at weather stations at the time of the Landsat overpass. Moreover, if statistically significant relationships can be determined between station measurements and snowfall in unmonitored areas, the recorded history of snowfall at the stations might be used to estimate long-term conditions in the unmonitored areas.

## METHODS AND MATERIALS

### Study Areas

Two 25-by-25 km test areas in upstate New York were selected for analysis (Figs. 1 and 2). Each area exhibits contrasting land use and cover, including urban, residential, agriculture, forest, water bodies and marsh (Fig. 3). The topography in both areas is gently undulating, except along the steep-sided lake or river valleys.

### Ground Data

Data on snow were obtained from the Climatological Data Bulletin

of New York State (NOAA, 1973-78). Reported in this bulletin are daily values for snowfall and the depth of snow on the ground at 64 stations throughout the state.

The 22 stations selected for inclusion in this study are listed in Table 1; their locations are shown in Figure 1. The criteria for station selection were threefold: the stations must have complete data on snow observations; the times for observing the depth of snow on the ground must be reasonably close to the time of the Landsat overpass; and the stations should be geographically representative of New York State.

## Satellite Images and Snowfall

The selection of Landsat scenes required that the study area be cloud-free and that some amount of snow be reported at at least one of the 22 stations. Cloud cover was a major problem; only 12 scenes (dates) were found suitable in the western test area, and the same number of scenes was used in the eastern test area (Table 2). The snow depths recorded at the 22 stations on these dates ranged from 0 to 24 in (61 cm). Trace amounts of snow were included as 0.01 in (0.25 mm).

Earlier investigators have found images from Landsat band 5 (red, 0.6-0.7μm) to be best for mapping snow because of the distinct spectral contrast between snow and snow-free areas, and because snow boundaries in the infrared images (bands 6 and 7) can be affected by snow melt (Barnes and Smallwood, 1975; O'Brien and Munis, 1975).

Nevertheless, only Landsat band 7 (0.8-1.1μm) images were acquired for analysis. Band 7 images offer good spectral contrast between snow and snow-free areas, they are less subject to atmospheric haze than band 5 images, and they offer superior contrast between water and land or snow--the latter being important for establishing map control in the study areas.

## Image Analysis

The analysis of snow from the 12 Landsat band 7 images of each test area (i.e., 24 images) was conducted with a Bausch & Lomb Zoom Transfer Scope. Each black-and-white image was optically superimposed on a 1:250,000 scale base map on which lakes and rivers had been traced from a U.S. Geological Survey topographic map. Also compiled on each base map was the 625 sq km test area, delineated and subdivided into 25 5-by-5 km cells (Fig. 3). Through visual analysis of the Landsat image tones, a percentage snow cover was estimated for each cell. This step was performed using a second acetate grid which subdivided the 5-by-5 km cells into 100 units (0.25 sq km or 25 hectare units). The percentage snow cover in each cell on each date was enumerated and recorded, with each cell being labeled by the two digit row-column numbers shown in Figure 3.

## Statistical Analysis

Initially, the 12 sets (dates) of snow depth measurements at the 22 stations and the corresponding 12 sets of Landsat-derived snow

cover measurements for each of 25 cells, in each test area, were input to a simple linear correlation routine ("Correlation with Transgeneration," BMD02D from the UCLA Health Sciences Computing Facility). Station versus station, cell versus cell, and station versus cell correlations were computed in an effort to ascertain general relationships. Subsequently, a multiple linear regression routine ("Stepwise Regression," BMD02R) was employed to assess how accurately the percentage of snow cover in any cell could be estimated from station snow depth measurements.

## RESULTS AND DISCUSSION

### Estimating Snow Cover

The results of the stepwise regression analysis are summarized in Table 3. Included are the first three stations to enter into an equation for estimating snow cover in each cell, along with the coefficient of multiple determination, $R^2$, and the standard error of estimate that resulted from the addition of each station.

The station versus cell correlations in Table 3 can be analyzed to provide insight into snowfall patterns. In the western test area, the correlations reflect the general direction of snowfall in the region, with Rochester in the northwest (Station R) exhibiting the highest correlation with 24 of the 25 cells. For the eastern test area, the pattern is much less defined. Stations to the west exhibit the highest correlation with 18 of the 25 cells, but the correlations are low.

As is also clear from the values in Table 3, the extent of snow cover in many cells could be reliably estimated from station snow depth measurements. This is especially true in the western test area, where the inclusion of no more than three stations could account for at least 93% of the variability in snow cover, and reduce the standard error of estimate to 11% or less, in every cell. For 20 of the 25 cells, only two stations were needed to account for at least 90% of the variability in Landsat-derived snow cover, and only one station could account for at least 90% of the variability in almost one-third of the cells.

Although the reliability of snow cover estimates was much lower in the eastern test area, the inclusion of three stations could account for at least 50% of the variability in every cell, and at least 65% of the variability in 17 of the 25 cells (Table 3). Further, the inclusion of a fourth station could account for at least 60% of the variability in snow cover estimates in every cell, and at least 75% of the variability in 18 of the 25 cells (results not shown).

The higher reliability of snow cover estimates in the western test area is partly attributed to the greater amounts of forest cover in the eastern area, and to the regularity associated with the lake effects, which would be more pronounced in the western area. Notably, improved results might be obtained with nonlinear regression models.

In general, inputting long-term snow data from the station records

to the multiple regression equation for many of the cells--particularly those in the western test area--should provide reliable estimates of the historic occurrence of snow in those cells. In this manner, for example, it should be possible to estimate the average historic dates of the earliest and latest snowfall, as well as the continuity of snowfall in areas quite removed from weather stations. These estimates will affect planning for recreation, in addition to being of significance for hydrologic and other studies.

## Estimating Snow Depth

Although the immediate aim of this study was to develop a technique for estimating the extent of snow cover in unmonitored areas, the ability to estimate snow depth would be of even greater value. Based on the station versus station correlations (results not shown), it is felt that estimation of snow depth should also be possible.

For the 12 dates considered in the western test area, all but two of the 22 stations exhibited $r^2$ values exceeding 0.85 with at least one other station, and most had at least one $r^2$ value of 0.90 or above. Snow depths recorded at Utica (Station U), for example, exhibited $r^2$ values over 0.90 when correlated with snow depths recorded at five other stations; Syracuse (Station S) exhibited values over 0.90 with four other stations. Comparable results were obtained with most stations for the 12 dates considered in the eastern area.

The indications are strong that snow depth as well as snow cover can also be estimated from snow depth measurements at certain key weather stations. This might be tested with a relatively short-

term (1-2 year) sampling program wherein snow depth in an area of interest is monitored and the snowfall correlated with snowfall recorded at stations in the region.

## Eliminating/Relocating Snow Measuring Stations

Given the high correlations between snow depths at several stations and the desirability of cost savings, it is possible that certain snow measuring stations might be eliminated. Such action must, of course, be based on statistical analysis of longer term records which are readily available. Further study of this possibility is beyond the scope of a remote sensing investigation.

One other consideration that could affect station location arises from an examination of the cell versus cell correlations, summarized in Table 4. Included in the table are the mean value of the correlation, r, between snow cover in one cell and snow cover in the 24 other cells in the test area, together with the standard error and range in r values. In general, cells exhibiting high correlation with many other cells (e.g., cell 25 in western area) would be prime locations for establishing new stations. Snow depth measurements at a station within these key cells should provide values from which to estimate snowfall in the correlated cells. On the other hand, if a cell shows low correlation with all other cells, (e.g., cell 15 in eastern area), this might also be a prime location for establishing a new station. Obtaining reliable estimates of snowfall in these areas would be otherwise impossible.

## SUMMARY AND CONCLUSIONS

In this investigation, the number of observations was low and the chance for introducing error was relatively high--image and ground measurements were not concurrent, forested areas affected Landsat image interpretations, and all Landsat-derived values were subjective. It was demonstrated, however, that the percentage of snow cover in upstate New York test areas was correlated with, and could be reliably estimated by, snow depths recorded at weather stations in the region. The formulation of regression equations for estimating snow cover from station measurements could thus be used to estimate long-term snowfall conditions in areas without weather stations.

As was shown, this type of analysis might also be extended to studies of estimating snow depths, as well as be applicable in evaluating the need and location of existing and future snow measuring stations.

## ACKOWLEDGMENTS

The authors would like to thank Dr. Warren W. Knapp, Associate Professor of Atmospheric Sciences at Cornell, for his helpful suggestions regarding the development of this study. The authors would also like to acknowledge the support of Dr. Ta Liang, Professor of Remote Sensing at Cornell, and NASA Grant NGL 33-010-171.

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Table 1. Names and observation times of selected snow measuring stations in New York State.

| | STATION | TIME (A.M.) | | STATION | TIME (A.M.) |
|---|---|---|---|---|---|
| A | Albany | 7:00 | L | Little Valley | 7:00 |
| B | Alfred | 8:00 | M | Massena | 7:00 |
| C | Aurora R. | 8:00 | N | Mt Morris | 8:00 |
| D | Binghamton | 7:00 | O | N.Y.C. Central Park | 7:00 |
| E | Buffalo | 7:00 | P | Poughkeepsie | 7:00 |
| F | Canton | 8:00 | Q | Prattsburg | 7:00 |
| G | Cornell U. | 8:00 | R | Rochester | 7:00 |
| H | Elizabethtown | 8:00 | S | Syracuse | 7:00 |
| I | Frienship | 7:00 | T | Tupper Lake | 8:00 |
| J | Glens Falls | 7:00 | U | Utica | 7:00 |
| K | Gloversville | 7:00 | V | Walton | 7:00 |

Table 2. Landsat band 7 images employed for analysis.

| DATE | IDENTIFICATION NO. | DATE | IDENTIFICATION NO. |
|---|---|---|---|
| | Western Study Area | | |
| 3/23/73 | E-1243-15244 | 2/27/76 | E-2401-15091 |
| 3/24/73 | E-1244-15303 | 12/30/76 | E-2708-15051 |
| 12/19/73 | E-1514-15270 | 3/11/77 | E-2779-14564 |
| 2/10/74 | E-1567-15200 | 3/12/77 | E-2780-15022 |
| 3/18/74 | E-1603-15190 | 3/29/77 | E-2797-14555 |
| 1/13/76 | E-5269-14490 | 3/30/77 | E-2798-15013 |
| | Eastern Study Area | | |
| 1/08/73 | E-1169-15123 | 4/03/74 | E-1619-15071 |
| 1/09/73 | E-1170-15182 | 2/03/75 | E-1925-14565 |
| 2/13/73 | E-1205-15130 | 1/02/76 | E-2345-14581 |
| 11/10/73 | E-1475-15101 | 12/10/76 | E-2688-14541 |
| 2/09/74 | E-1566-15135 | 3/09/77 | E-2777-14451 |
| 2/27/74 | E-1584-15134 | 3/27/77 | E-2795-14440 |

Table 3. Parameters of stepwise linear regression equations for estimating percentage snow cover in cells from snow depth at stations. (Stepwise order of stations, STA, coefficient of multiple determination, $R^2$, and standard error of estimate, SE)

| | 1ST VARIABLE | | | 2ND VARIABLE | | | 3RD VARIABLE | | |
|---|---|---|---|---|---|---|---|---|---|
| CELL | STA | $R^2$ | SE | STA | $R^2$ | SE | STA | $R^2$ | SE |
| | | | | **Western Test Area** | | | | | |
| 11 | R | 86 | 16 | E | 93 | 12 | L | 95 | 11 |
| 12 | R | 92 | 12 | E | 96 | 9 | I | 99 | 6 |
| 13 | R | 89 | 15 | E | 96 | 9 | A | 98 | 7 |
| 14 | R | 86 | 17 | E | 93 | 13 | P | 97 | 9 |
| 15 | R | 91 | 13 | E | 95 | 10 | N | 99 | 5 |
| 21 | R | 92 | 10 | O | 94 | 9 | T | 97 | 7 |
| 22 | R | 91 | 13 | D | 94 | 11 | B | 96 | 9 |
| 23 | R | 81 | 18 | D | 92 | 13 | Q | 98 | 6 |
| 24 | R | 83 | 17 | D | 95 | 10 | Q | 98 | 6 |
| 25 | R | 89 | 14 | E | 95 | 10 | A | 99 | 5 |
| 31 | R | 93 | 10 | J | 96 | 8 | K | 98 | 6 |
| 32 | R | 89 | 12 | F | 98 | 8 | T | 99 | 7 |
| 33 | R | 77 | 20 | D | 93 | 12 | Q | 98 | 7 |
| 34 | R | 79 | 16 | D | 89 | 12 | I | 98 | 6 |
| 35 | R | 75 | 18 | D | 92 | 11 | J | 97 | 7 |
| 41 | R | 67 | 12 | T | 89 | 11 | M | 94 | 9 |
| 42 | R | 92 | 10 | M | 95 | 9 | H | 97 | 7 |
| 43 | R | 83 | 13 | M | 92 | 10 | H | 96 | 8 |

Table 3. (Continued)

| | 1ST VARIABLE | | | 2ND VARIABLE | | | 3RD VARIABLE | | |
|---|---|---|---|---|---|---|---|---|---|
| CELL | STA | $R^2$ | SE | STA | $R^2$ | SE | STA | $R^2$ | SE |
| 44 | R | 84 | 10 | M | 93 | 7 | L | 94 | 7 |
| 45 | R | 80 | 11 | M | 91 | 8 | C | 93 | 7 |
| 51 | B | 96 | 6 | A | 98 | 4 | G | 99 | 3 |
| 52 | R | 94 | 9 | E | 96 | 7 | T | 97 | 7 |
| 53 | R | 81 | 10 | U | 86 | 9 | G | 99 | 3 |
| 54 | R | 74 | 12 | D | 89 | 8 | Q | 98 | 4 |
| 55 | R | 71 | 11 | S | 86 | 8 | N | 93 | 6 |
| | | | | Eastern Test Area | | | | | |
| 11 | U | 26 | 15 | P | 58 | 12 | D | 67 | 11 |
| 12 | U | 42 | 12 | S | 68 | 9 | L | 79 | 8 |
| 13 | G | 38 | 14 | S | 53 | 13 | L | 78 | 9 |
| 14 | L | 36 | 7 | M | 54 | 6 | T | 68 | 6 |
| 15 | T | 43 | 5 | U | 59 | 5 | G | 72 | 4 |
| 21 | S | 37 | 7 | T | 52 | 6 | J | 60 | 6 |
| 22 | U | 24 | 10 | S | 44 | 9 | F | 55 | 9 |
| 23 | H | 27 | 17 | L | 57 | 14 | A | 68 | 13 |
| 24 | G | 34 | 18 | R | 52 | 16 | U | 70 | 13 |
| 25 | L | 41 | 18 | E | 58 | 16 | C | 71 | 14 |
| 31 | E | 44 | 5 | J | 68 | 4 | I | 80 | 4 |
| 32 | U | 32 | 6 | H | 43 | 6 | F | 51 | 6 |
| 33 | T | 22 | 13 | H | 50 | 11 | F | 66 | 10 |
| 34 | L | 38 | 22 | H | 61 | 18 | E | 71 | 17 |

Table 3. (Continued)

| CELL | 1ST VARIABLE STA | $R^2$ | SE | 2ND VARIABLE STA | $R^2$ | SE | 3RD VARIABLE STA | $R^2$ | SE |
|---|---|---|---|---|---|---|---|---|---|
| 35 | L | 35 | 22 | H | 54 | 20 | P | 65 | 18 |
| 41 | E | 34 | 3 | L | 42 | 3 | I | 64 | 3 |
| 42 | H | 50 | 4 | C | 62 | 3 | O | 69 | 3 |
| 43 | H | 28 | 14 | I | 55 | 12 | E | 81 | 8 |
| 44 | L | 32 | 23 | H | 58 | 19 | P | 66 | 18 |
| 45 | U | 33 | 25 | P | 54 | 22 | L | 66 | 20 |
| 51 | U | 13 | 6 | O | 43 | 5 | J | 57 | 5 |
| 52 | F | 30 | 5 | T | 43 | 5 | O | 59 | 4 |
| 53 | T | 17 | 4 | O | 28 | 4 | U | 54 | 3 |
| 54 | G | 23 | 23 | R | 41 | 22 | J | 53 | 20 |
| 55 | L | 32 | 23 | H | 60 | 19 | E | 68 | 18 |

Table 4. Mean, standard error and range in correlations between percentage snow cover in one cell versus all other cells.

| | CORRELATION, r | | | | CORRELATION, r | | |
|---|---|---|---|---|---|---|---|
| CELL | MEAN | SE | RANGE | CELL | MEAN | SE | RANGE |
| | | | Western Test Area | | | | |
| 11 | .899 | .057 | .761-.987 | 41 | .917 | .038 | .853-.976 |
| 12 | .932 | .049 | .814-.994 | 42 | .934 | .033 | .828-.985 |
| 13 | .937 | .048 | .826-.994 | 43 | .910 | .039 | .813-.985 |
| 14 | .935 | .047 | .787-.985 | 44 | .927 | .046 | .767-.964 |
| 15 | .949 | .042 | .805-.993 | 45 | .923 | .055 | .704-.962 |
| 21 | .898 | .058 | .817-.978 | 51 | .782 | .052 | .649-.852 |
| 22 | .943 | .041 | .820-.992 | 52 | .945 | .036 | .852-.993 |
| 23 | .942 | .050 | .777-.997 | 53 | .912 | .044 | .788-.968 |
| 24 | .945 | .053 | .741-.993 | 54 | .923 | .060 | .739-.994 |
| 25 | .952 | .039 | .830-.993 | 55 | .875 | .071 | .649-.958 |
| 31 | .918 | .051 | .744-.984 | | | | |
| 32 | .942 | .040 | .804-.985 | | | | |
| 33 | .933 | .060 | .720-.994 | | | | |
| 34 | .937 | .050 | .774-.997 | | | | |
| 35 | .923 | .065 | .695-.995 | | | | |

Table 4. (Continued)

| CELL | CORRELATION, r MEAN | SE | RANGE | CELL | CORRELATION, r MEAN | SE | RANGE |
|---|---|---|---|---|---|---|---|
| | | | Eastern Test Area | | | | |
| 11 | .583 | .231 | .119-.901 | 41 | .384 | .164 | .131-.784 |
| 12 | .591 | .264 | .010-.876 | 42 | .576 | .197 | .010-.784 |
| 13 | .630 | .288 | .014-.927 | 43 | .672 | .257 | .157-.925 |
| 14 | .653 | .215 | .189-.914 | 44 | .726 | .249 | .083-.991 |
| 15 | .147 | .147 | .010-.343 | 45 | .716 | .248 | .047-.992 |
| 21 | .382 | .149 | .171-.710 | 51 | .381 | .182 | .059-.713 |
| 22 | .626 | .284 | .016-.935 | 52 | .284 | .153 | .010-.491 |
| 23 | .637 | .296 | .078-.935 | 53 | .369 | .127 | .063-.570 |
| 24 | .700 | .282 | .121-.983 | 54 | .630 | .264 | .146-.967 |
| 25 | .684 | .254 | .097-.969 | 55 | .724 | .270 | .187-.983 |
| 31 | .276 | .168 | .090-.772 | | | | |
| 32 | .574 | .222 | .230-.839 | | | | |
| 33 | .598 | .260 | .059-.967 | | | | |
| 34 | .713 | .258 | .136-.985 | | | | |
| 35 | .696 | .257 | .017-.976 | | | | |

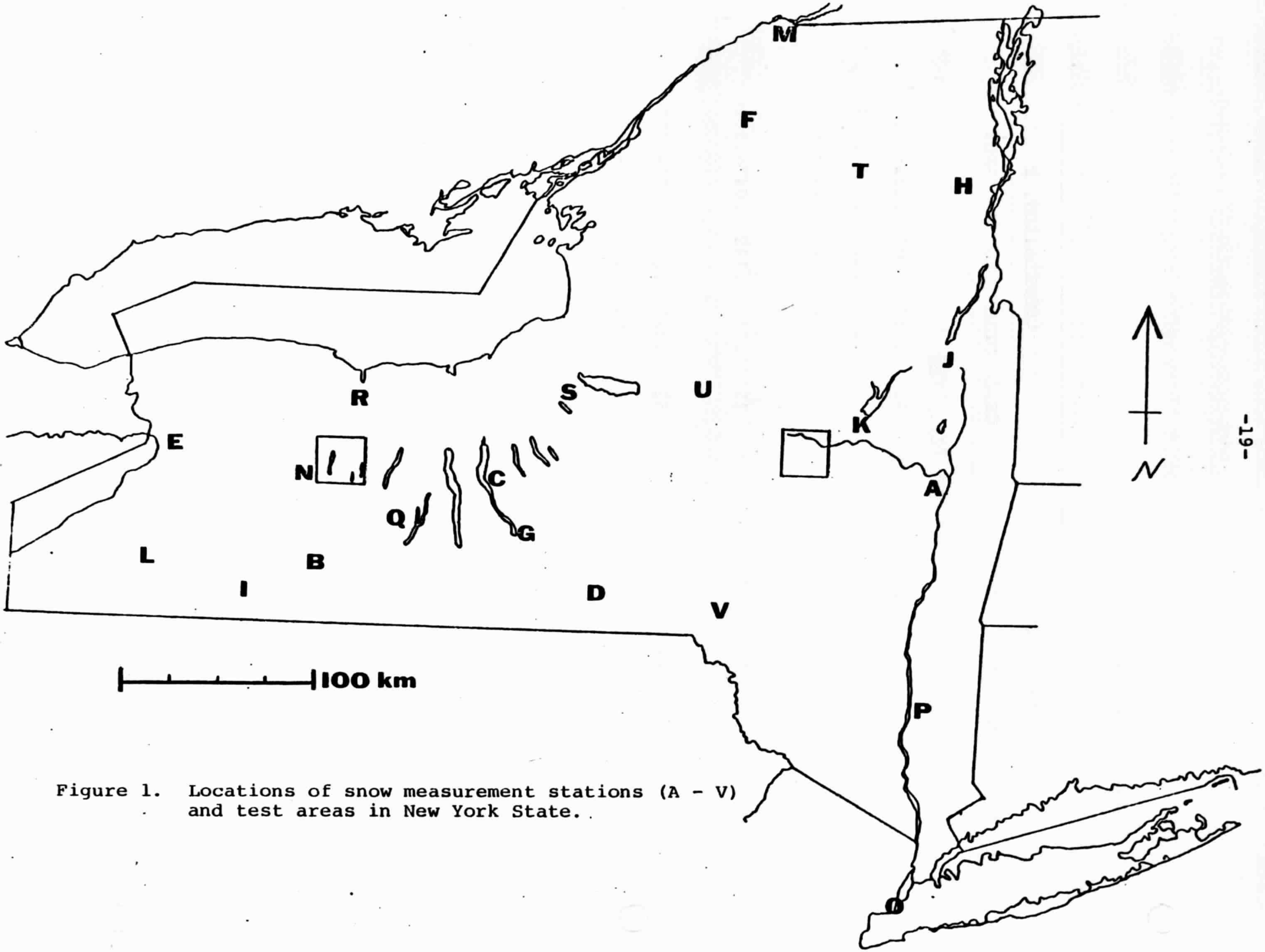



Figure 1. Locations of snow measurement stations (A - V) and test areas in New York State.

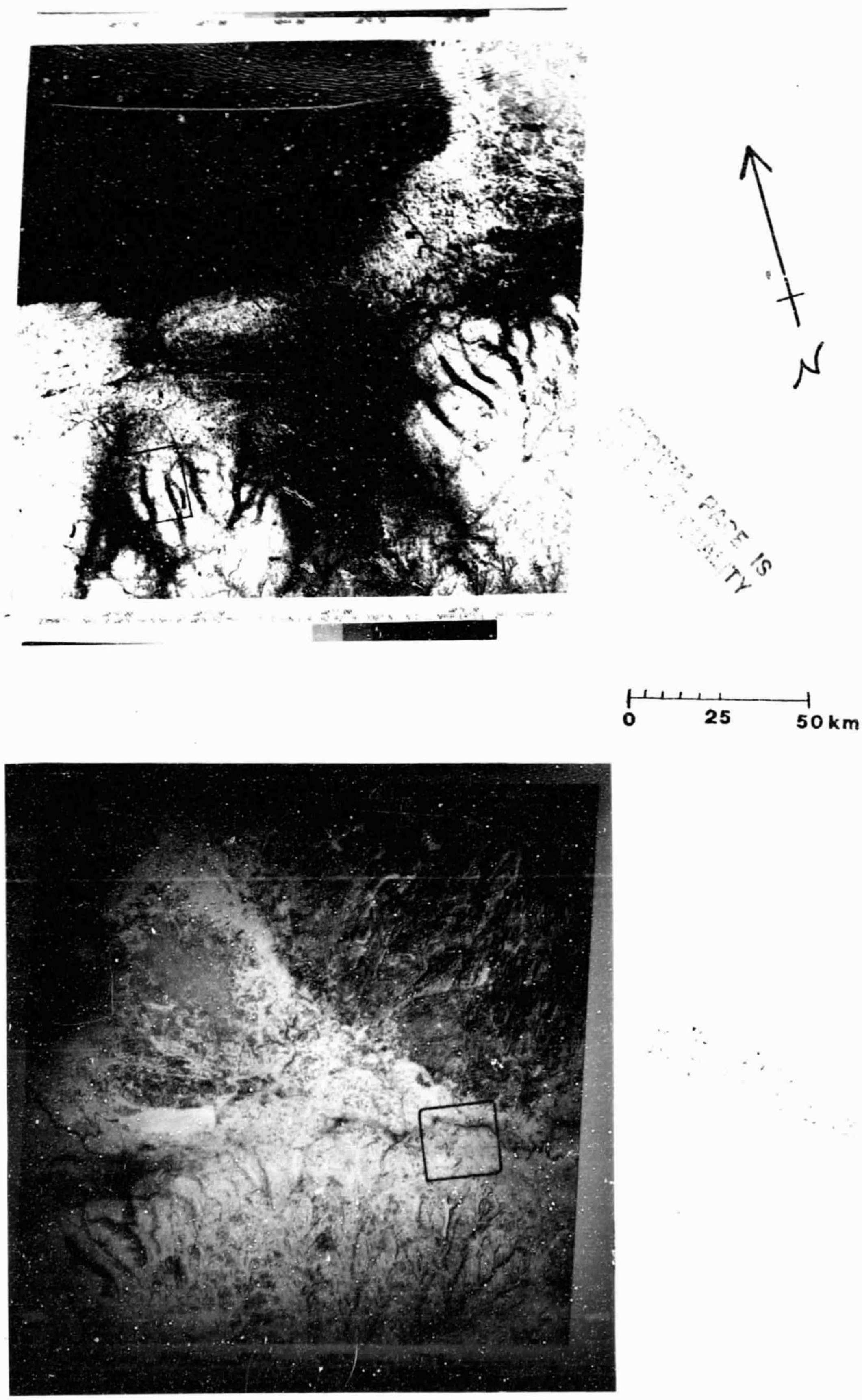



Figure 2. Landsat images of western test area (top) and eastern test area (bottom).

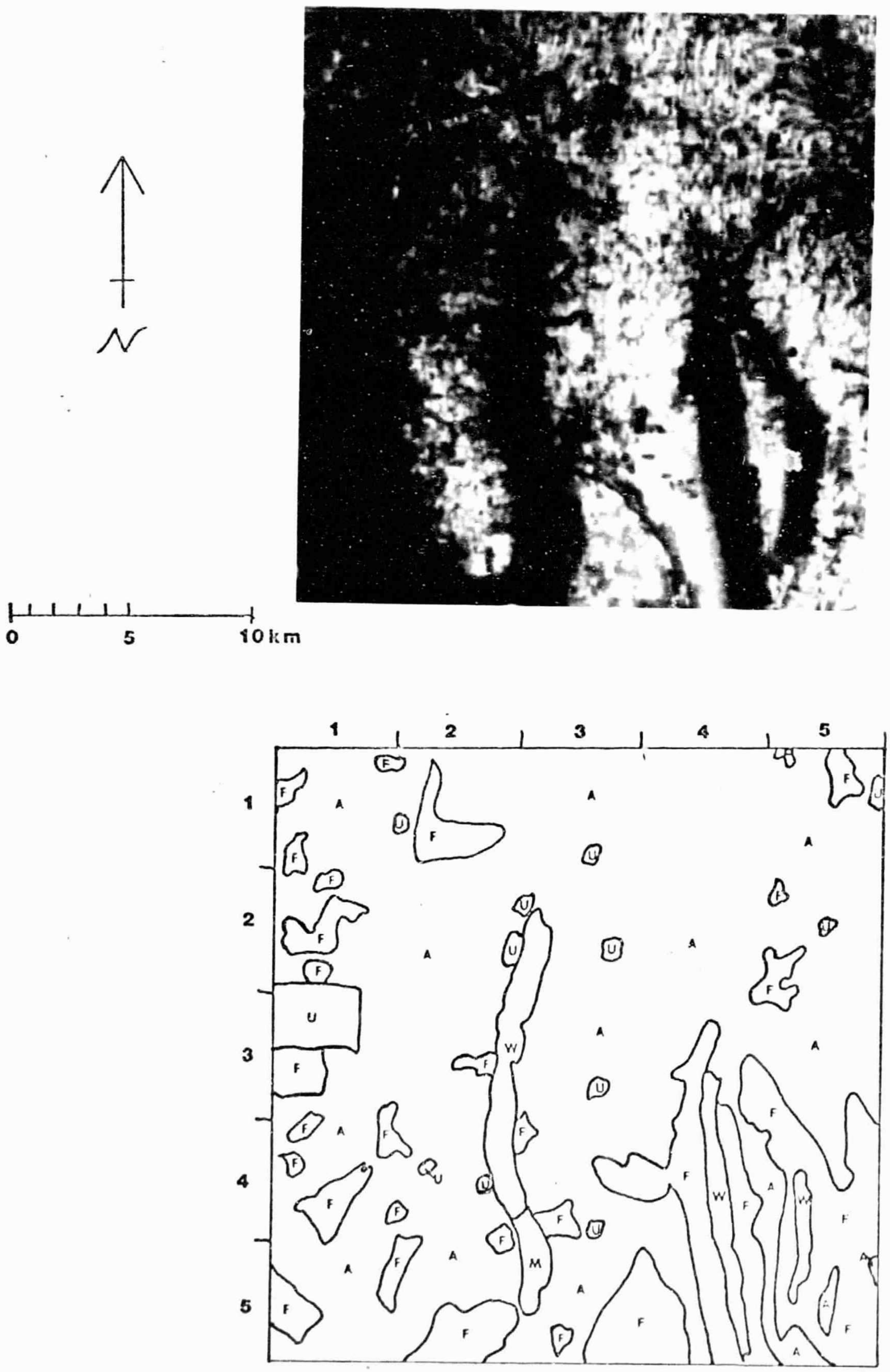
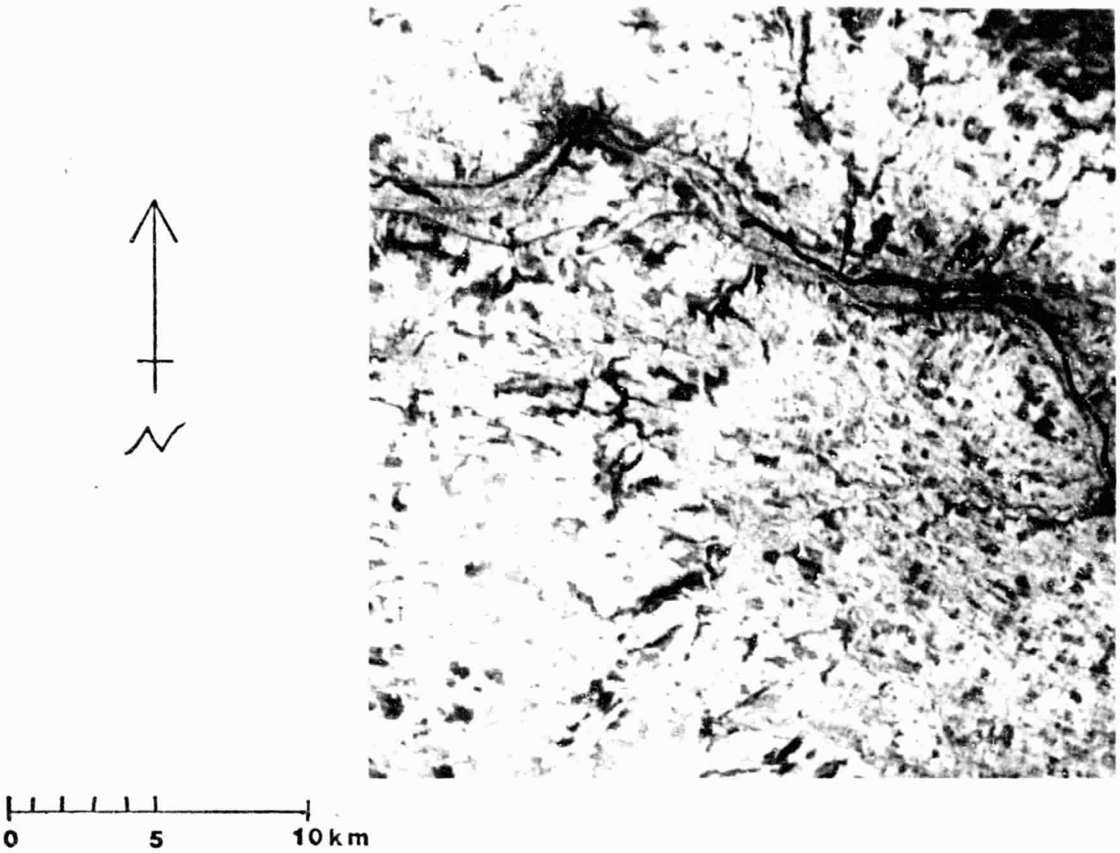



Figure 3a. Western test area; enlarged portion of Landsat image (top) and land cover map derived from aerial photographs (bottom).



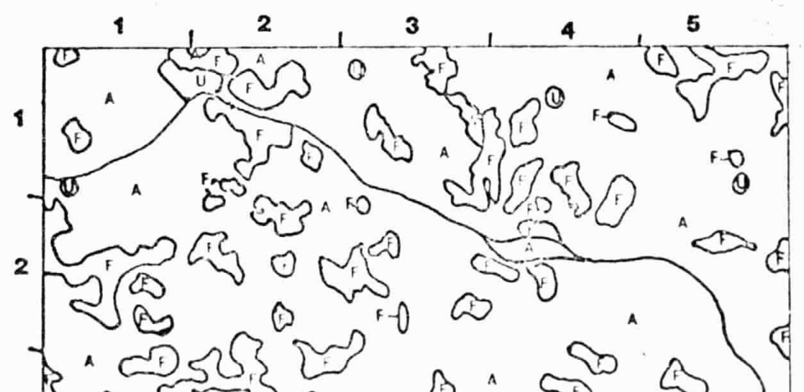






Figure 3b. Eastern test area; enlarged portion of Landsat image (top) and land cover map derived from aerial photographs (bottom).

Figure 3. (Continued)

KEY

| SYMBOL | DOMINANT LAND COVER |
|---|---|
| A | Agricultural land; includes active and inactive cropland, pasture, farm homesteads and access roads |
| W | Water body |
| F | Forest; includes deciduous, coniferous and mixed stands, and/or brush |
| M | Marsh, possibly with some trees |
| U | Urban center; includes residential areas |

# APPENDIX B

Airphoto Inventory of Abandoned Oil Wells
in Allegany State Park, N.Y.

# AIRPHOTO INVENTORY OF ABANDONED OIL WELLS IN ALLEGANY STATE PARK, N. Y.

Remote Sensing Program
Cornell University
Hollister Hall
Ithaca, New York 14853

May 1980

## PREFACE

This study was performed at the request of Dr. Peter J. R. Buttner, Director of Environmental Management, of the New York State Office of Parks and Recreation. Funding was provided by NASA Grant NGL 33-010-171.

The work was completed by Lisa K. Balliett under the direction of Warren R. Philipson. Assistance was provided by William R. Hafker.

Ta Liang
Principal Investigator

## INTRODUCTION

The Allegany State Park in southwestern New York (Fig. 1) was once exploited for its oil deposits. Since abandoned without reclamation, the open oil wells are potentially hazardous to hikers as well as being unrestricted avenues for ground water contamination.

The New York State Office of Parks and Recreation has begun a program to locate the abandoned oil wells and apply corrective measures -- redrilling, filling and covering with a concrete cap. To date, the locations of 120 wells have been supplied by the drilling companies. This study was undertaken to determine if any additional abandoned oil wells could be found using remotely sensed data.

## METHODS AND MATERIALS

### Sources of Information

The remotely sensed and auxiliary data examined in searching for abandoned oil wells in the 60,200 acre Allegany State Park included several dates of aerial photographs, topographic maps, and the Park Inventory Map of known abandoned oil wells (Table 1).

### Development of Airphoto Legend

Based on stereoscopic analysis of the aerial photographs and comparison with the auxiliary data and the extensive network of oil wells just outside the Park boundaries, it was found that the identifying characteristics of an abandoned oil well were similar to those of gas wells or other park clearings (i.e., a small clearing, us[illegible]y in association with an access road or trail). As such, the legend developed for the airphoto inventory allowed for recognition of unknown ("new") abandoned oil wells with either a high or low degree of confidence.

A third category in the airphoto inventory legend identified those abandoned oil wells that were shown on the Park Oil Well Inventory Map and also detected on the photographs.

The fourth and final category in the legend was included after finding that the locations of several photo-interpreted abandoned wells were close, but not identical, to the locations o[illegible]lls shown on the Park Oil Well Inventory Map. These sites may actually [illegible]er to the same abandoned oil well, being displaced on the map or through the photo transfer process.

### Airphoto Inventory Procedures

The photo indexes of the 1939 coverage were studied using a desk magnifier. Three stereoscopic pairs of photographs, selected as being representative from the indexes, were obtained from the National Archives for closer examination. Overall, the photographs did not provide any more information on sites of abandoned oil wells than could be derived from the photo indexes. Therefore, no additional prints of the 1939 photography were acquired.

The 1955-56 aerial photographs were studied in detail using a pocket lens stereoscope, and the small scale, 1973 color infrared photographs were examined on a light table using a variable magnification (zoom) stereoscope.

The locations of the photo-interpreted, abandoned oil wells were compared to the well sites recorded on the Park Oil Well Inventory Map by optically superimposing each photograph or portion of a photo index onto the map using a Zoom Transfer Scope. In this manner, a composite map was compiled with the interpreted well sites shown in accordance with the legend described in Table 2. As a final step, acetate overlays showing the photo-interpreted well locations were made for each ninth of each topographic map (Figs. 2-12).

## RESULTS AND DISCUSSION

Based on the analysis of 1939, 1955-56 and 1973 aerial photographs, 92 previously unidentified, abandoned oil wells were found in New York's Allegany State Park (Table 2; Fig. 2-12). Of these, 46 were identified with a high degree of confidence and 46 with a low degree of confidence. Five additional sites of abandoned oil wells were identified, although they may actually be known wells whose locations are plotted incorrectly on the Park Oil Well Inventory Map.

Surprisingly, only two of the 120 abandoned wells shown on the Park Oil Well Inventory Map could be identified on at least one date of photographic coverage. The reasons for the low rate of confirmation might become clear if the dates of the inventoried wells could be ascertained.

In general, over half of the photo-interpreted, abandoned oil wells were derived from the 1939 coverage. A number of these wells, and about 15 additional wells, were identified with the September (leaf-on) 1956 photographs; no wells could be identified with the November (leaf-off) 1955 photographs. With the 1973 color infrared film, many clearings were easily identified, but most were associated with gas wells or other activities. Although about 25 wells were added with the color infrared film, none of the wells interpreted from 1939 or 1956 coverage was observable.

As a final note, it is emphasized that the results of this study are based on aerial photographic interpretation and, thus, subject to field check.

Table 1. Sources of information used in search for abandoned oil wells in Allegany State Park, N. Y.

AERIAL PHOTOGRAPHIC COVERAGE

| DATES/ SOURCES | APPROX. SCALE | TYPE |
|---|---|---|
| 19 Sept 1973/ NASA | 1:130,000 | color infrared film |
| *27 Sept 1956/ U.S. Dept. of Agriculture | 1:20,000 | panchromatic contact prints |
| *1 Nov 1955/ U.S. Dept. of Agriculture | 1:20,000 | panchromatic contact prints |
| 7 or 9 June 1939/ National Archives | 1:32,000 | photo indexes of panchromatic prints and |
| | 1:20,000 | selected contact prints |

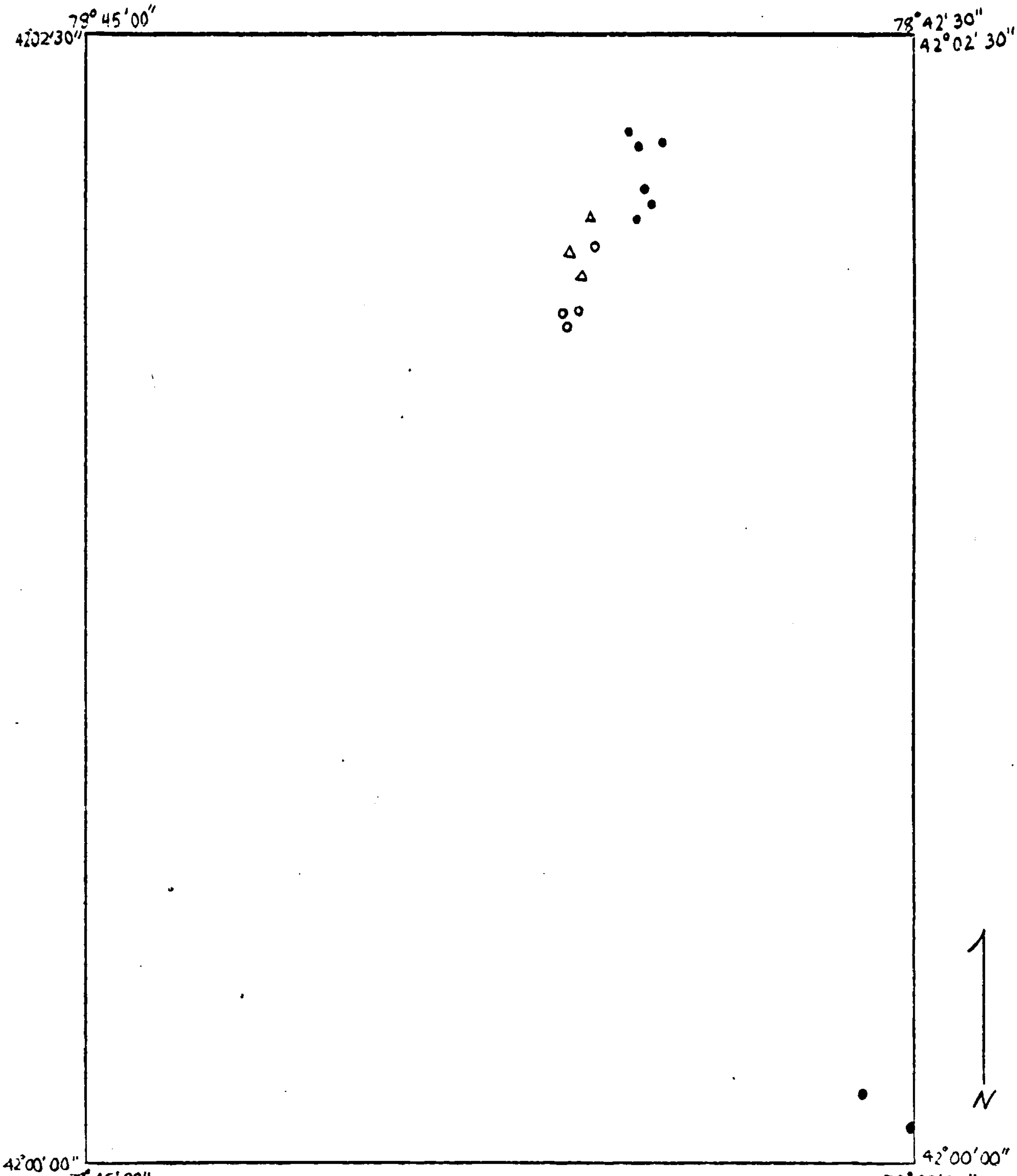
*Both dates of photography needed for complete Park coverage.

AUXILIARY DATA

- Park Inventory Map of known abandoned oil wells (annotated mosaic of 1:24,000 scale topographic maps)
- U.S. Geological Survey, 1:24,000 scale, 7.5 minute topographic maps (Limestone, Little Valley, Red House, Salamanca, Steamburg)

Figure 5.

LIMESTONE QUADRANGLE (G)




● "New" oil well - High confidence

○ "New" oil well - Low confidence

△ Displaced oil well from inventory map location

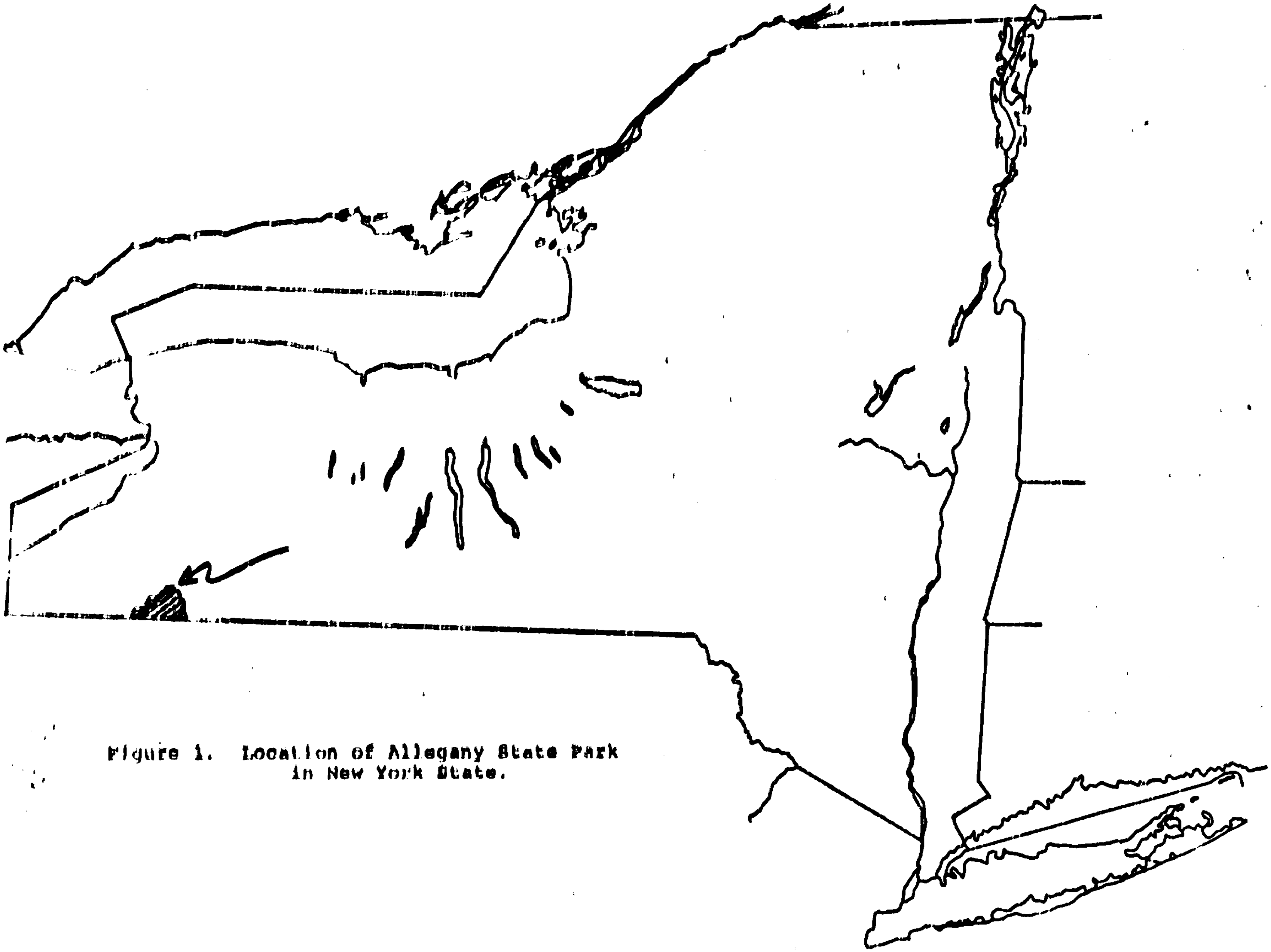
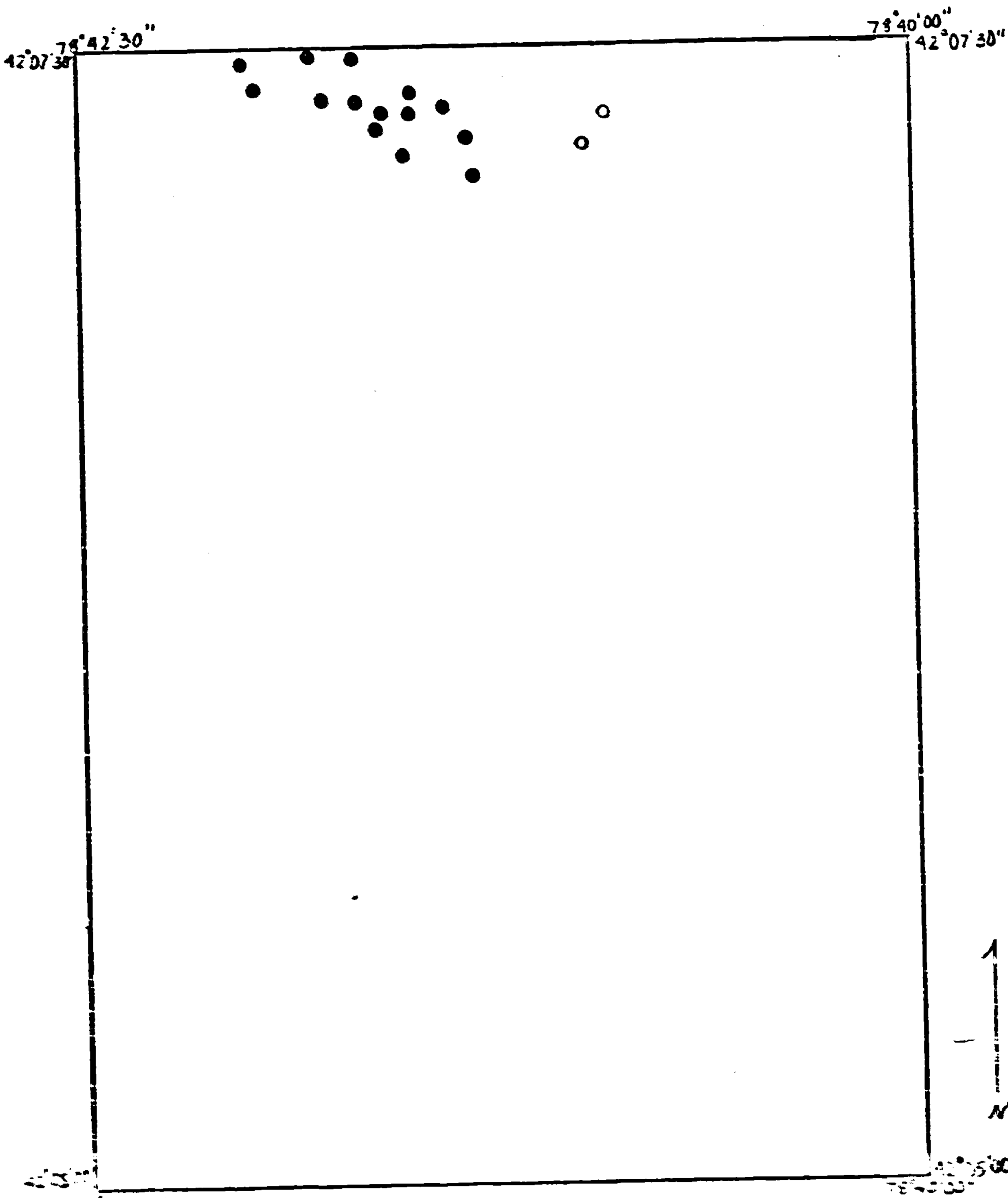


Figure 1. Location of Allegany State Park in New York State.

Figure 2.

LIMESTONE QUADRANGLE (B)

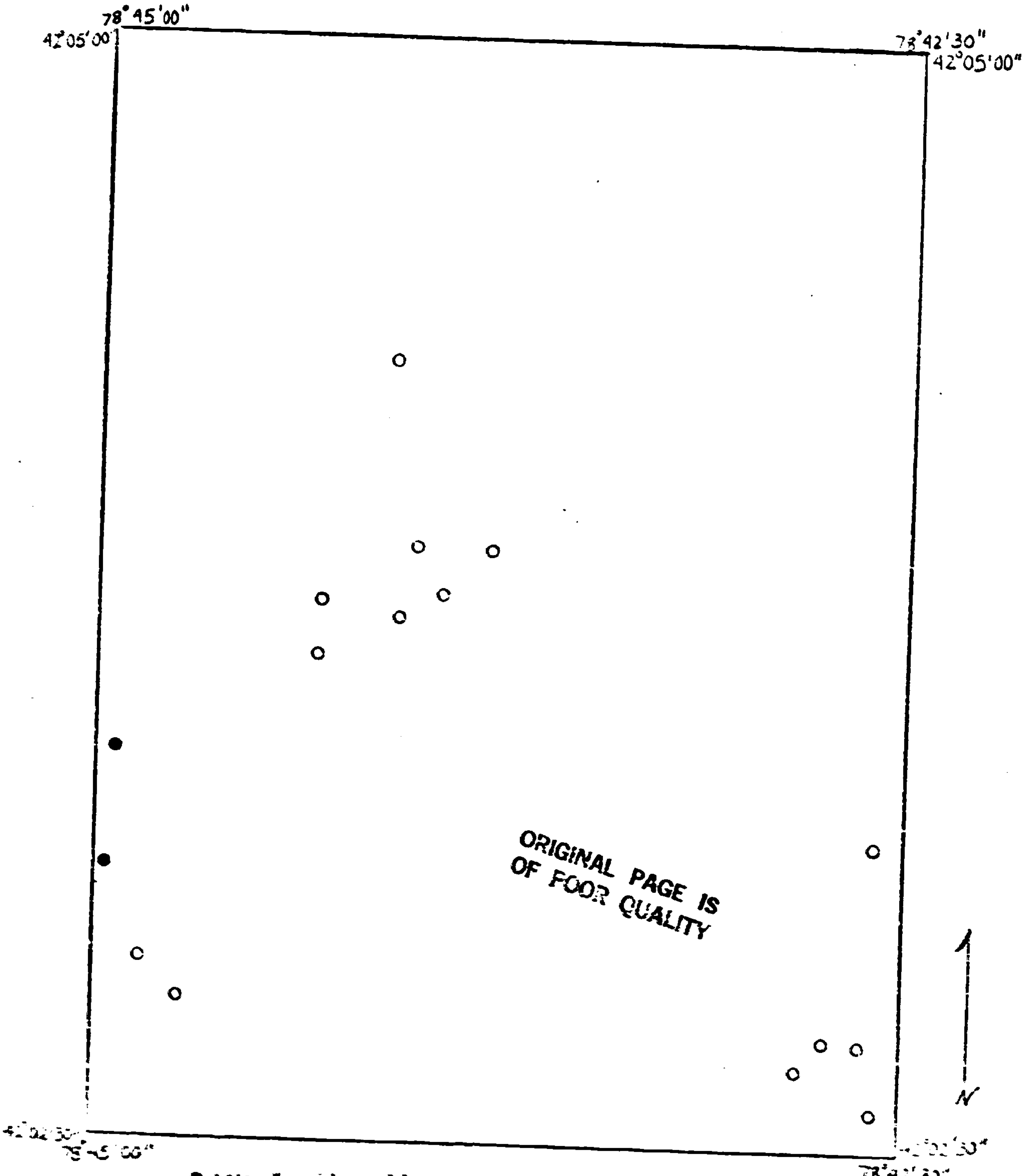



● "New" oil well - High confidence

o "New" oil well - Low confidence

Figure 3.

LIMESTONE QUADRANGLE (D)

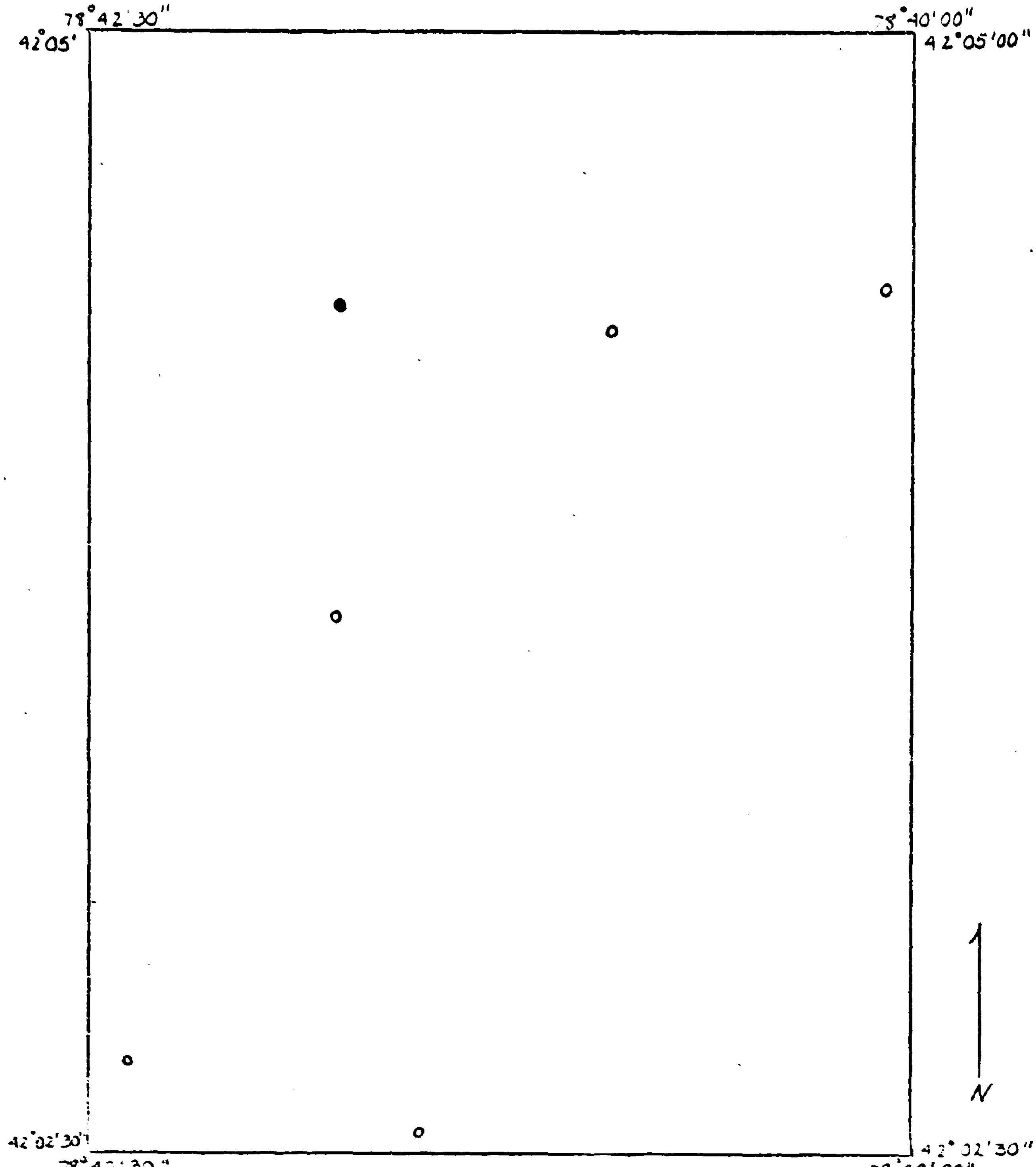



● "New" oil well - High confidence

○ "New" oil well - Low confidence

Figure 4.

LIMESTONE QUADRANGLE (E)

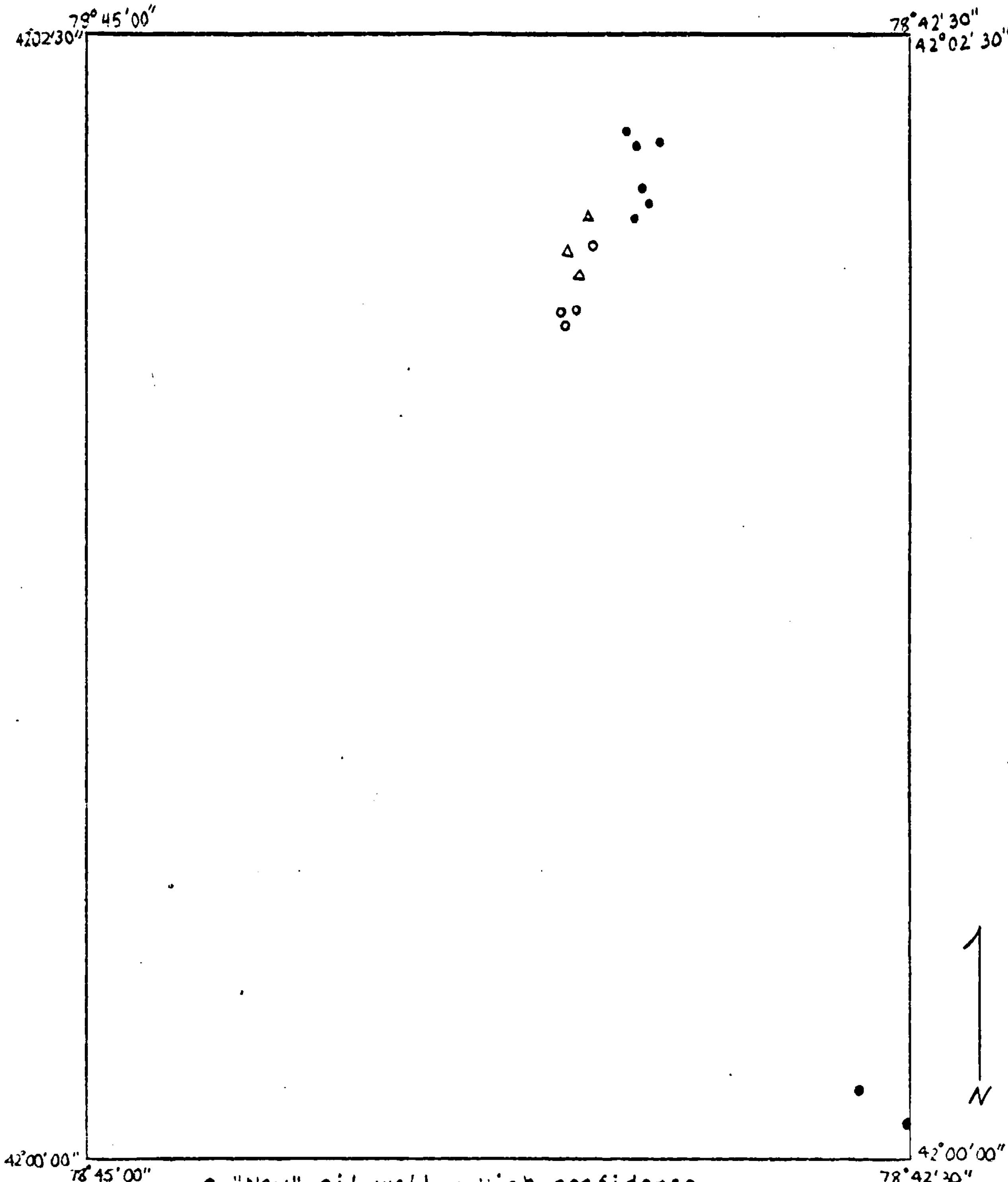



● "New" oil well - High confidence

o "New" oil well - Low confidence

Figure 5.

LIMESTONE QUADRANGLE (G)



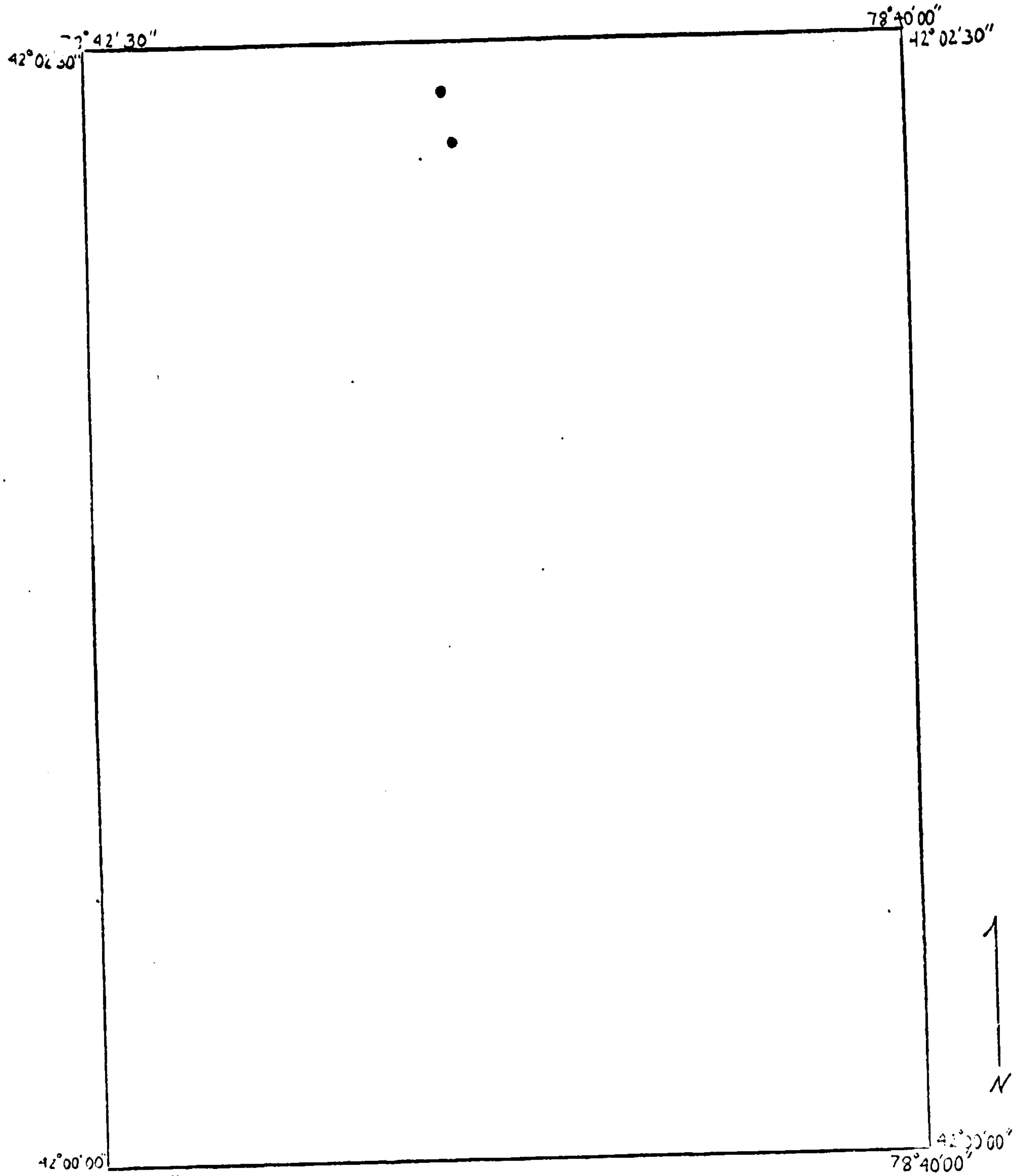

● "New" oil well - High confidence

○ "New" oil well - Low confidence

△ Displaced oil well from inventory map location

Figure 6.

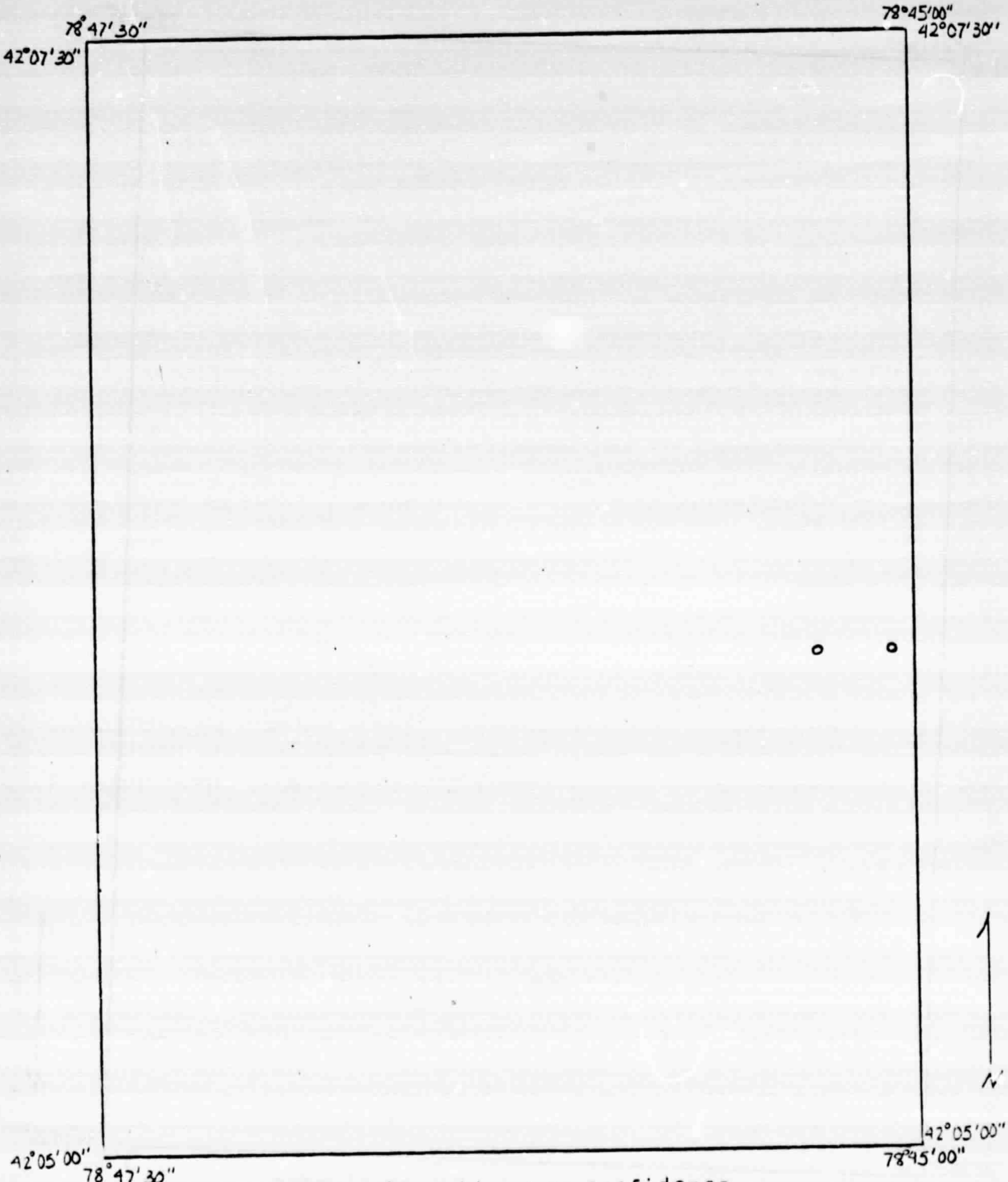
LIMESTONE QUADRANGLE (H)




● "New" oil well - High confidence

Figure 7.

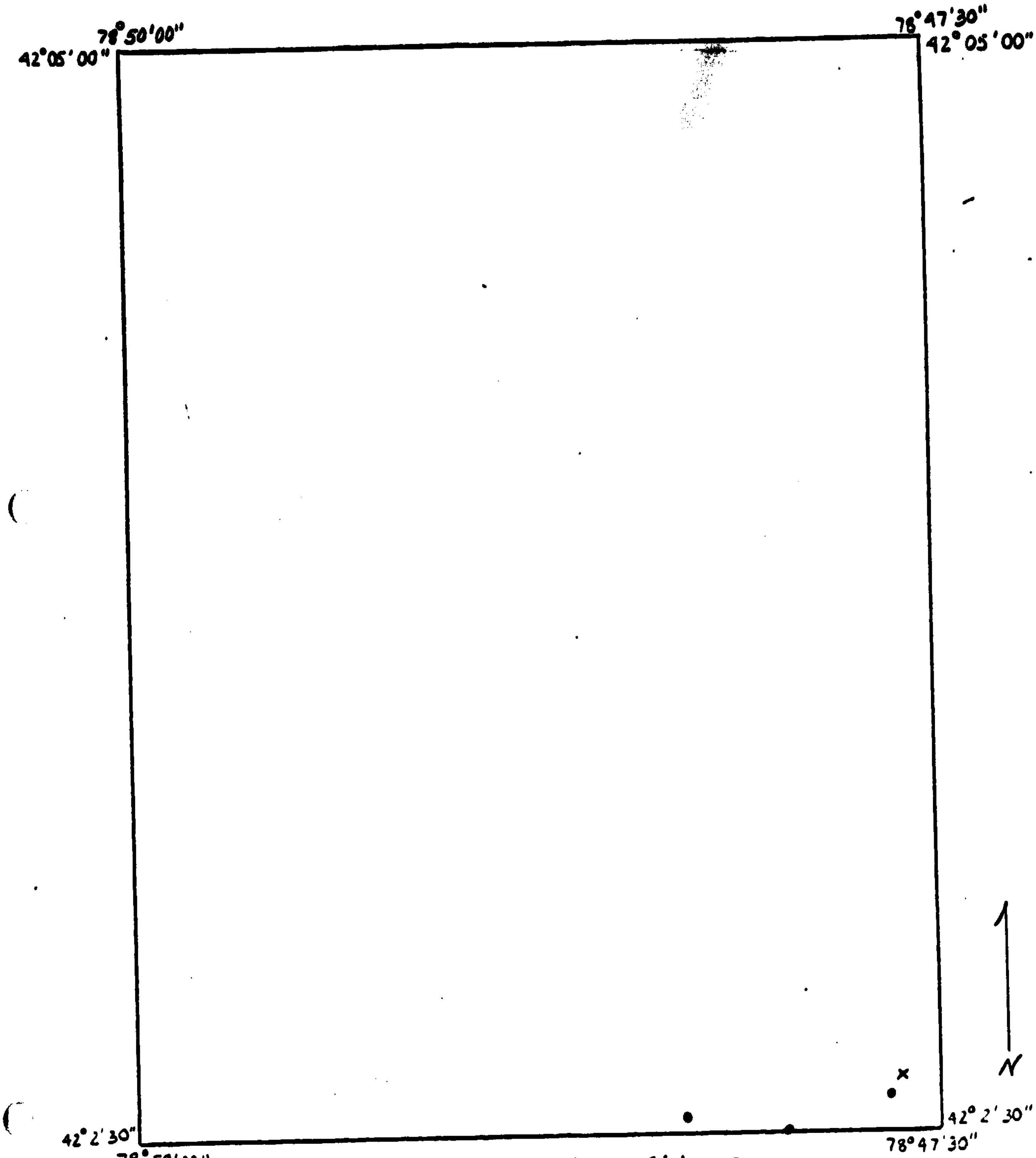
RED HOUSE QUADRANGLE(C)




o "New" oil well - Low confidence

# Figure 8.

RED HOUSE QUADRANGLE (E)

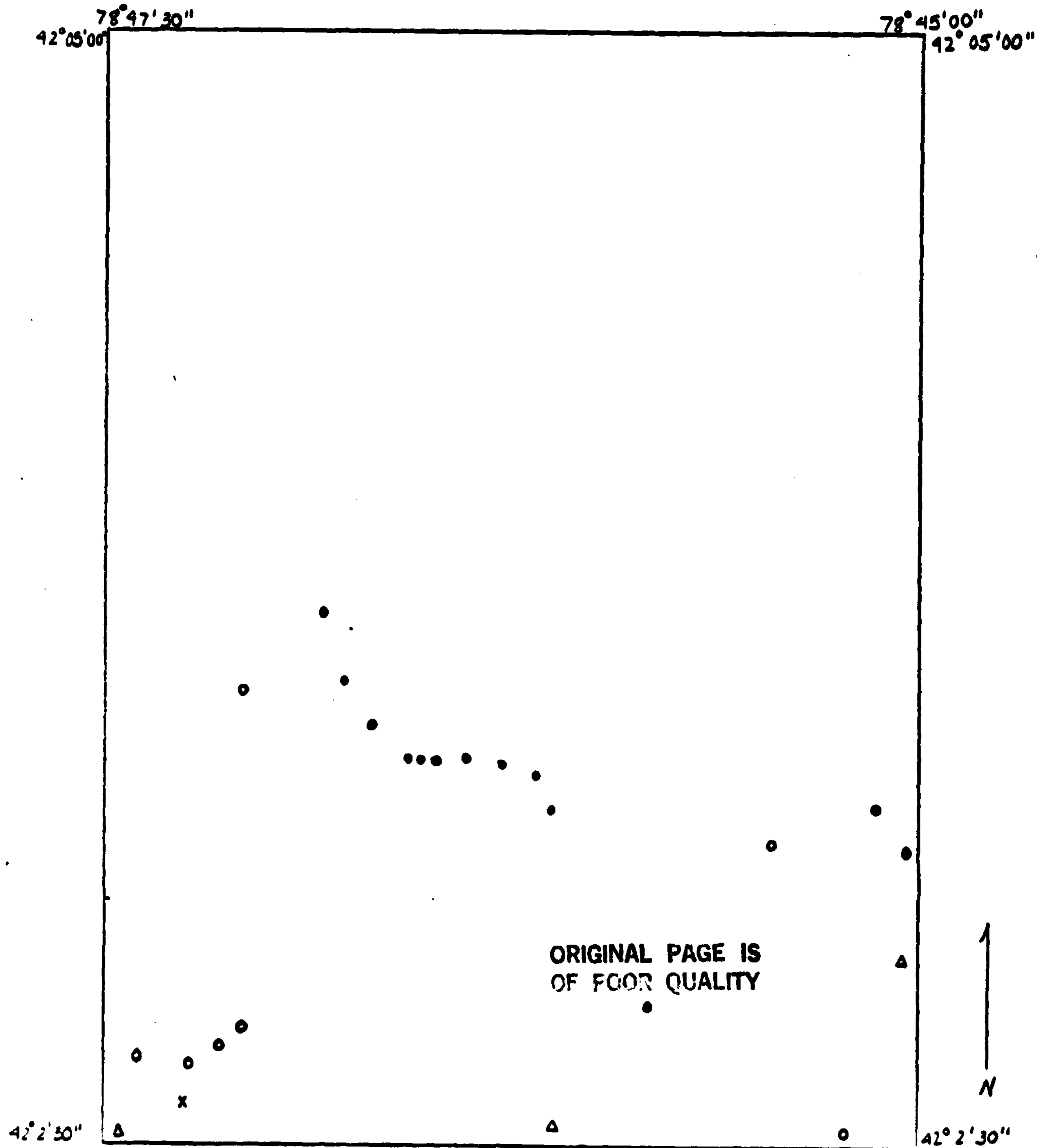



● "New" oil well - High confidence

x Oil well in ageement with park inventory map

Figure 9.

RED HOUSE QUADRANGLE (F)




● "New" oil well - High confidence

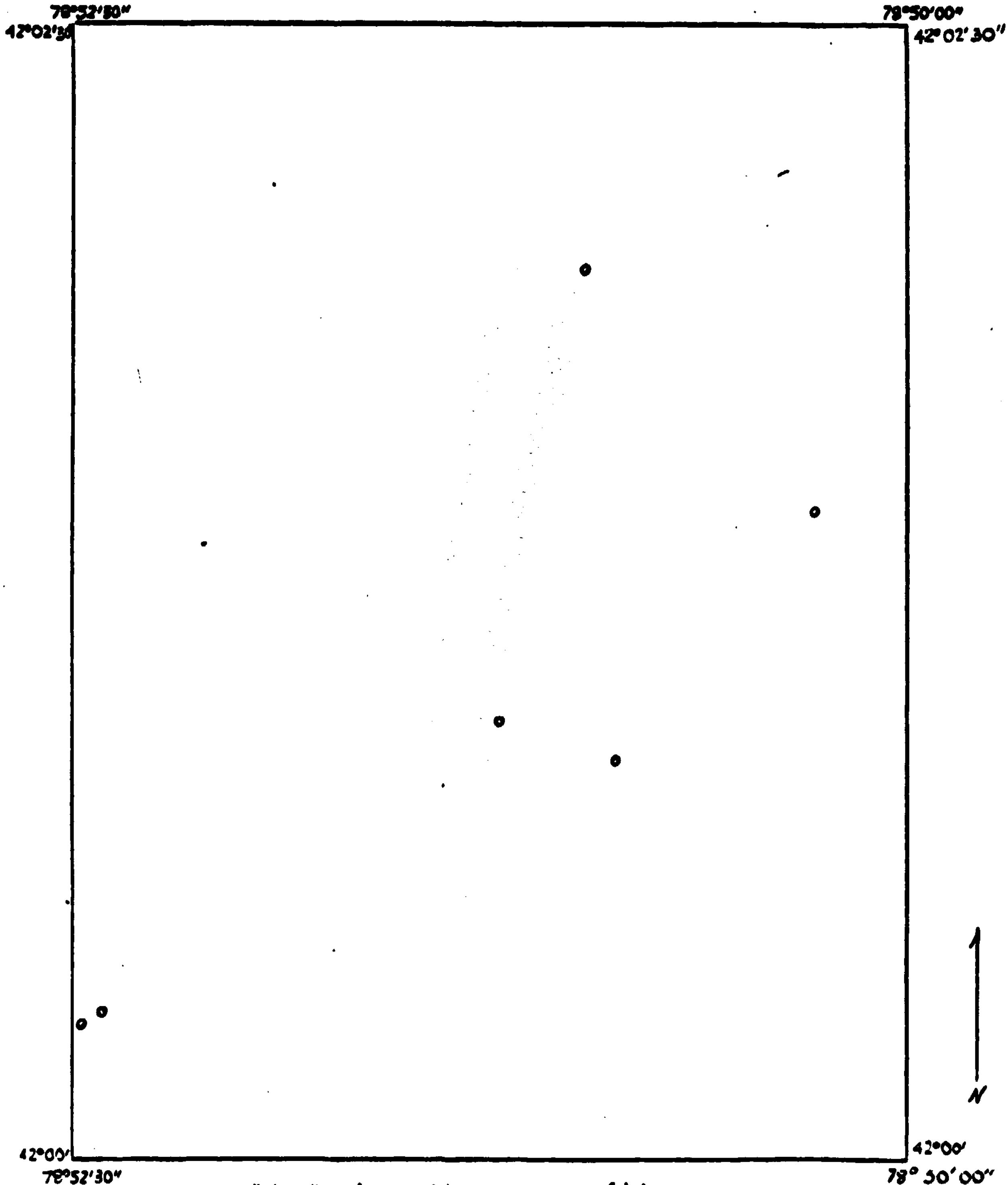
o "New" oil well - Low confidence

x Oil well in ageement with park inventory map

Δ Displaced oil well from inventory map location

Figure 10.

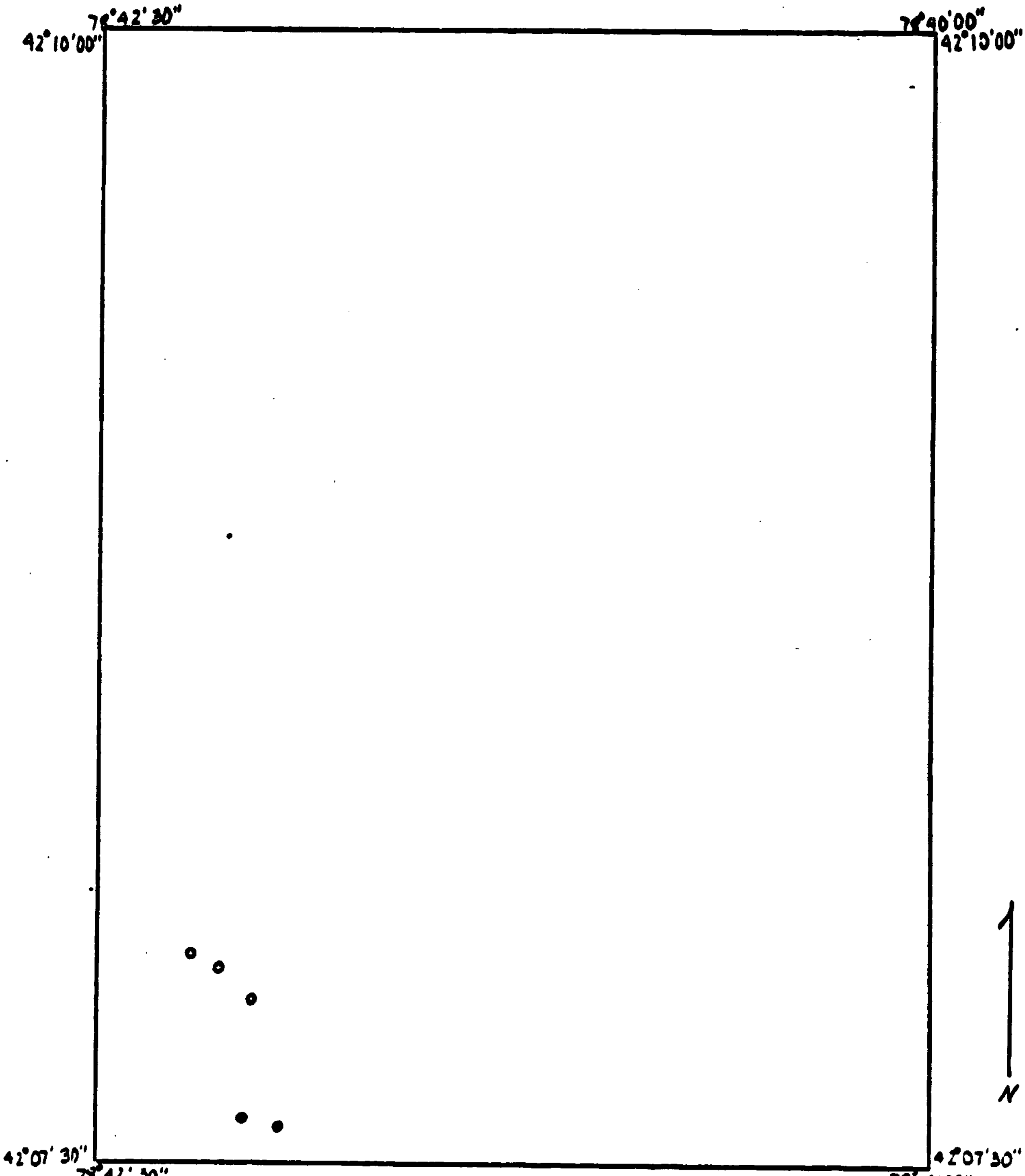
RED HOUSE QUADRANGLE (G)




o "New" oil well - Low confidence

Figure 11.

SALAMANCA QUADRANGLE (H)

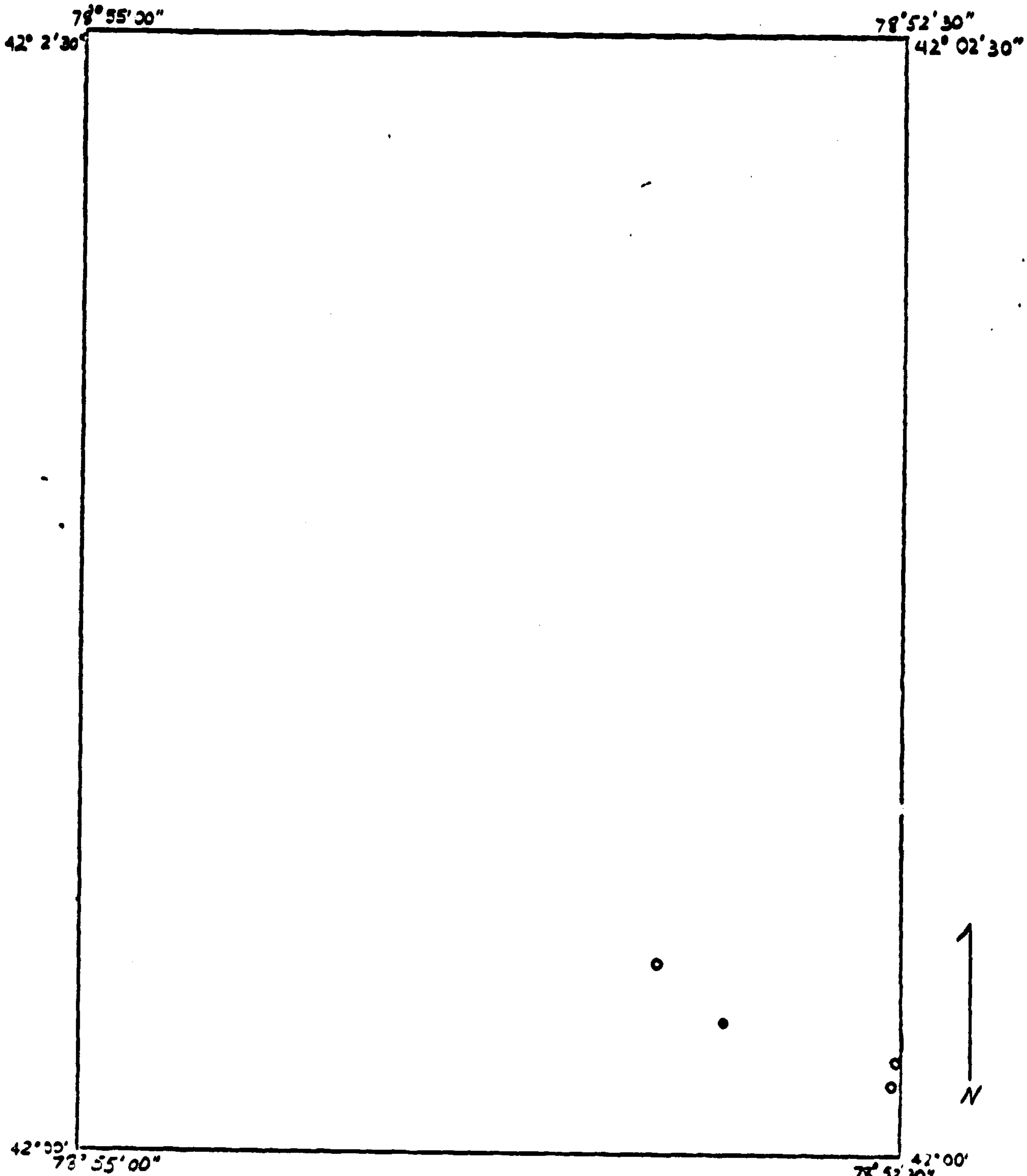



● "New" oil well - High confidence

o "New" oil well - Low confidence

Figure 12.

STEAMBURG QUADRANGLE (I)




● "New" oil well - High confidence

o "New" oil well - Low confidence

APPENDIX C

Research Paper on Vineyard Management

REMOTE SENSING FOR VINEYARD MANAGEMENT

W.R. Philipson, T.L. Erb, D. Fernandez and J.R. McLeester

p.[illegible]. In Proceedings of 46th Annual Meeting of American Society of Photogrammetry. (Held St. Louis, March 1980). American Society of Photogrammetry, Falls Church, Va.

# REMOTE SENSING FOR VINEYARD MANAGEMENT

W.R. Philipson, T.L. Erb, D. Fernandez and J.N. McLeester
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Ithaca, New York 14853

## BIOGRAPHICAL SKETCHES

Dr. Warren R. Philipson is an associate professor in Cornell's School of Civil and Environmental Engineering, where he has co-directed the Remote Sensing Program since 1972. Mr. Erb has also been associated with the Remote Sensing Program since 1972. A research specialist, he conducts remote sensing projects and lectures in airphoto interpretation. Messrs. David Fernandez and Jay N. McLeester are former undergraduate research assistants with the Program. Mr. Fernandez is currently president of a landscaping firm in Ithaca, N.Y., and Mr. McLeester is a photogrammetrist with Konski Engineers, in Syracuse, N.Y.

## ABSTRACT

Cornell's Remote Sensing Program has been involved in a continuing investigation to assess the value of remote sensing for vineyard management. Working primarily with the Taylor Wine Company, of Hammondsport, N.Y., Program staff members have conducted a series of site and crop analysis studies. These include: (1) panchromatic aerial photography for planning artificial drainage in a new vineyard; (2) color infrared aerial photography for assessing crop vigor/health; and (3) color infrared aerial photography and aircraft multispectral scanner data for evaluating yield related factors. These studies and their findings are reviewed.

## INTRODUCTION

Grapes are a major crop in New York State, with juice and wine-making being important industries. Since 1975, the Cornell Remote Sensing Program has been engaged in a series of studies aimed at determining the extent to which remote sensing can provide cost effective, useful information for vineyard management. All work has been conducted in cooperation with the Taylor Wine Company, Inc., of Hammondsport, N.Y. Funding has been provided under a grant from the National Aeronautics and Space Administration to Cornell's School of Civil and Environmental Engineering.

## CASE STUDY 1: NEW VINEYARD DRAINAGE ASSESSMENT

For the initial project, existing aerial photographs were used to evaluate the drainage needs of a planned [illegible] hectare ([illegible] acre) vineyard in [illegible], N.Y. The site was formerly a general farm, producing grain, vegetable and dairy products. Some older clay tile drainage was known to be in place, however, Taylor had to ensure that the future vines would have

# REMOTE SENSING FOR VINEYARD MANAGEMENT

W.R. Philipson, T.L. Erb, D. Fernandez and J.R. McLaughlin
Remote Sensing Program
Cornell University
Hollister Hall
Ithaca, New York 14853

## BIOGRAPHICAL SKETCHES

Dr. Warren R. Philipson is an associate professor in Cornell's School of Civil and Environmental Engineering, where he has co-directed the Remote Sensing Program since 1972. Mr. Erb has also been associated with the Remote Sensing Program since 1972. A research specialist, he conducts remote sensing projects and lectures in airphoto interpretation. Messrs. David Fernandez and Jay R. McLaughlin are former undergraduate research assistants with the Program. Mr. Fernandez is currently president of a landscaping firm in Ithaca, N.Y., and Mr. McLaughlin is a photogrammetrist with [illegible] Engineers, in Syracuse, N.Y.

## ABSTRACT

Cornell's Remote Sensing Program has been involved in a continuing investigation to assess the value of remote sensing for vineyard management. Working primarily with the Taylor Wine Company, of Hammondsport, N.Y., Program staff members have conducted a series of site and crop analysis studies. These include: (1) panchromatic aerial photography for planning artificial drainage in a new vineyard; (2) color infrared aerial photography for assessing crop vigor [illegible]; and (3) color infrared aerial photography and aircraft multispectral scanner data for evaluating yield related factors. These studies and their findings are reviewed.

## INTRODUCTION

Grapes are a major crop in New York State, with juice and wine-making being important industries. Since 1975, the Cornell Remote Sensing Program has been engaged in a series of studies aimed at determining the extent to which remote sensing can provide cost effective, useful information for vineyard management. All work has been conducted in cooperation with the Taylor Wine Company, Inc., of Hammondsport, N.Y. Funding has been provided under a grant from the National Aeronautics and Space Administration to Cornell's School of Civil and Environmental Engineering.

## CASE STUDY 1: NEW VINEYARD DRAINAGE ASSESSMENT

For the initial project, existing aerial photographs were used to evaluate the drainage needs of a planned [illegible] acre vineyard in [illegible], N.Y. The site was formerly a general farm, producing grain, vegetable and dairy products. [illegible] however, Taylor had to ensure that the future vines would have

a uniformly well-drained site. Taylor's usual procedure for planning artificial drainage involved walking a cleared field after a rain to locate wet spots.

Methods and Materials

In assessing the site, Cornell staff compiled a 1:5,000 scale sketch map, using a Zoom Transfer Scope to transfer contours from a 1:24,000 scale U.S. Geological Survey topographic map. Soil mapping units from the county soil survey report were also compiled, but because county-level surveys are normally of insufficient detail for analyzing site conditions, principal data on site drainage were derived from the available aerial photographic coverage. The photographs were panchromatic, 1:24,000 in scale, and they had been flown eight years earlier, in April 1968.

Site drainage conditions were assessed through stereoscopic analysis of the aerial photographs, placing emphasis on tone. The lower, darker toned areas were generally associated with poorer drained soils. Units interpreted and delineated on the contact prints corresponded to areas posing "slight," "moderate" or "severe" drainage limitations for grapevines. Also interpreted from the photographs were the locations of existing tile drainage. These normally appeared as contrasting toned, linear features, which were too straight to be natural. All photographic delineations were enlarged to the scale of the base map.

Results and Discussion

The vineyard site drainage information submitted to the Taylor Wine Company is shown in Figure 1 (Drainage Limitations) and Figure 2 (Existing Tile Drainage). Also submitted was a general plan for the new drainage network.

Based on this information, some 11,600 meters (38,000 feet) of plastic piping were placed on the 67 hectare (165 acre) site. Of special value to the field operations was a sketch of existing tile drains (Fig. 2). All of the photo-identified tile lines were still functioning. Other lines encountered in the field, but not observed on the photographs, were plugged or broken. Where possible, the functioning tile lines were incorporated into the new drainage network, thereby reducing the overall cost for site preparation.

Site preparation was completed during the summer of 1975, and planting commenced during the spring of 1976. To date, no underdrainage problems have been experienced.

CASE STUDY 2: ASSESSING GRAPEVINE VIGOR

As a follow-up to the drainage analysis of a new vineyard site, Cornell staff used aerial photographs to assess crop vigor/health in growing vineyards. Large scale color infrared aerial photographs of a wide range of grapevines were acquired in August 1977 by the Eastman Kodak Company. The fields photographed included those with first-year vines as well as fields with mature, producing vines of many varieties.

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Based on this information, some 11,600 meters (38,000 feet) of plastic piping were placed on the 7 hectare (17 acre) site. Of special value to the field operations was a sketch of existing tile drains (Fig. 2). All of the photo-identified tile lines were still functioning. Other lines encountered in the field, but not observed on the photographs, were plugged or broken. Where possible, the functioning tile lines were incorporated into the new drainage network, thereby reducing the overall cost for site preparation.

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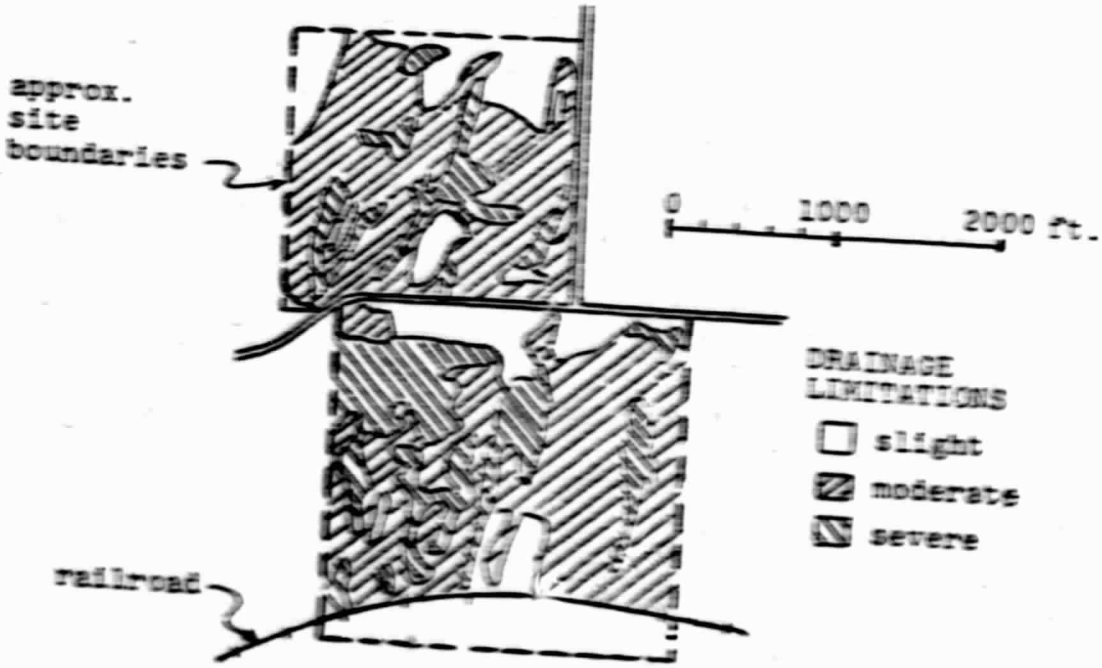
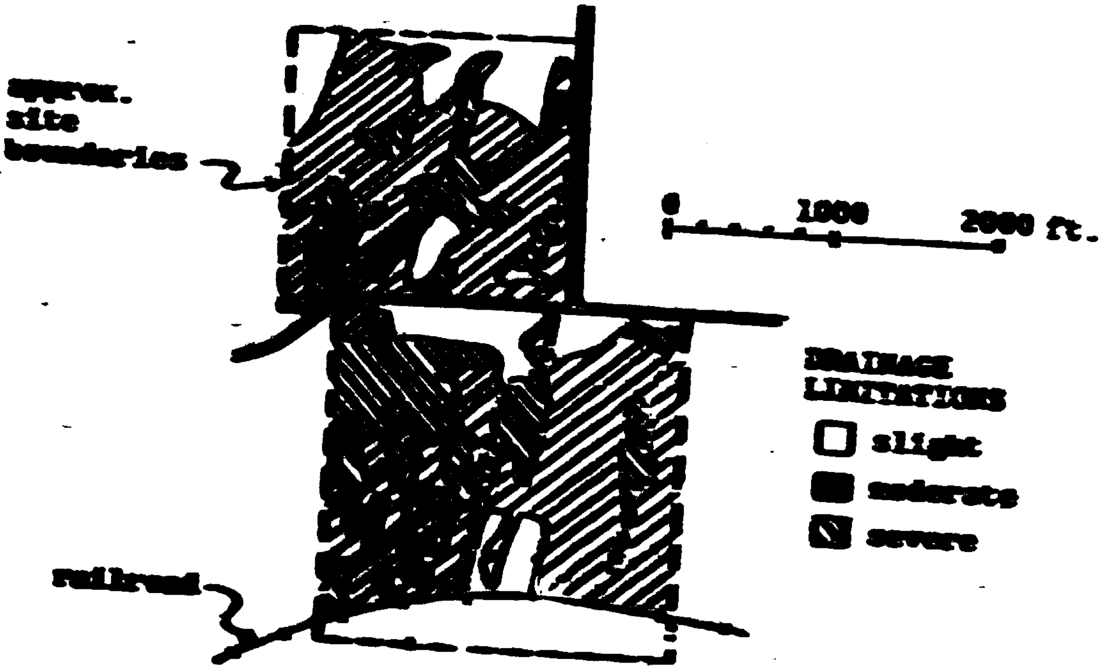



Figure 1. Airphoto interpreted drainage limitations in planned vineyard site in Ovid, N.Y.


Figure 2. Airphoto interpreted tile drains occurring in planned vineyard site in Ovid, N.Y.

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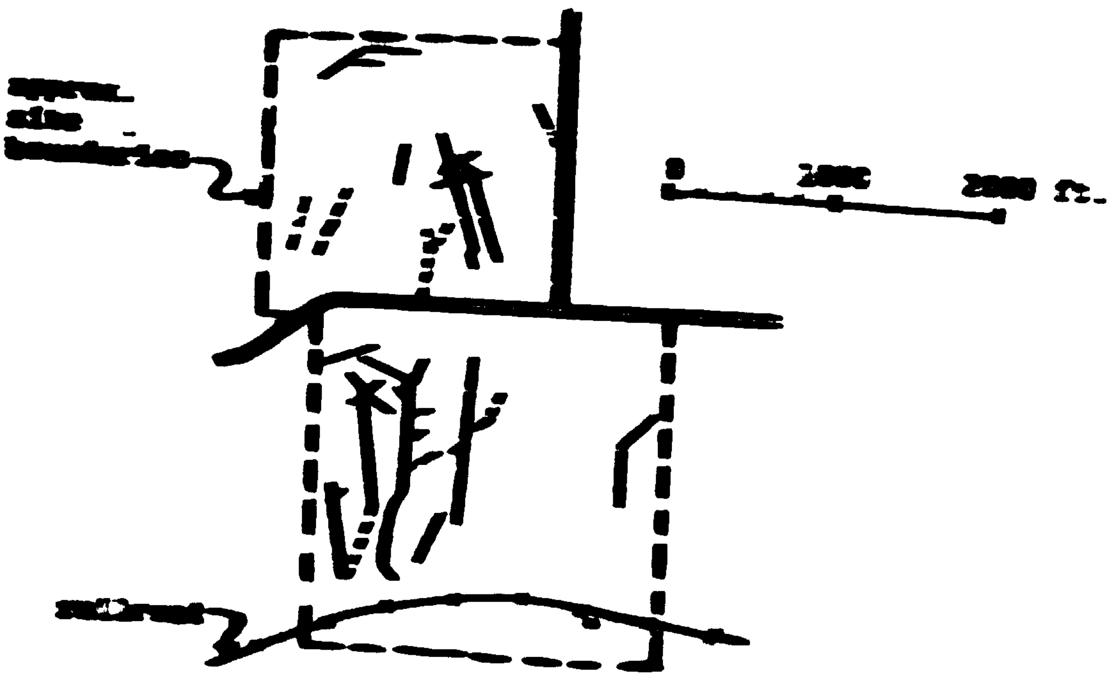


Figure 2. Airphoto interpreted tile drains occurring in planned vineyard site in Ovid, N.Y.

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As a trial submission to the Taylor vineyards manager, each vine or vine location in a portion of a field with first-year vines was categorized as: (1) high vigor, (2) average vigor, (3) low vigor, (4) very low vigor or gap, (5) gap or dead plant, or (6) double plant (Fig. 3). The categorization was based on visual analysis using a zoom stereoscope and light table.

Field checking with the vineyards manager demonstrated the potential value of the remote sensing approach: perfect agreement with the photographic ratings was obtained. (The double plant was found to be a vine and a corn plant, the field have previously been planted to corn.) Although the airphoto analysis could produce highly accurate and detailed information, it became apparent that the information was too detailed. For the purpose of managing tens of thousands of vines, generalized field delineations were judged to be of greater value. As such, final submissions to Taylor Wine showed areas dominated by low vigor plants and/or gaps within each field photographed (Fig. 4). These photo-derived data have provided the basis for increasing management levels in low vigor areas.

## CASE STUDY 3: VINEYARD YIELD ANALYSIS

Cornell staff next set out to examine relationships between vineyard crop yields and those morphologic or spectral characteristics of the vines that could be measured through remotely sensed data. It was believed that these relationships co ld provide insight into vineyard crop management practices and, at least to some extent, be applicable in estimating yield.

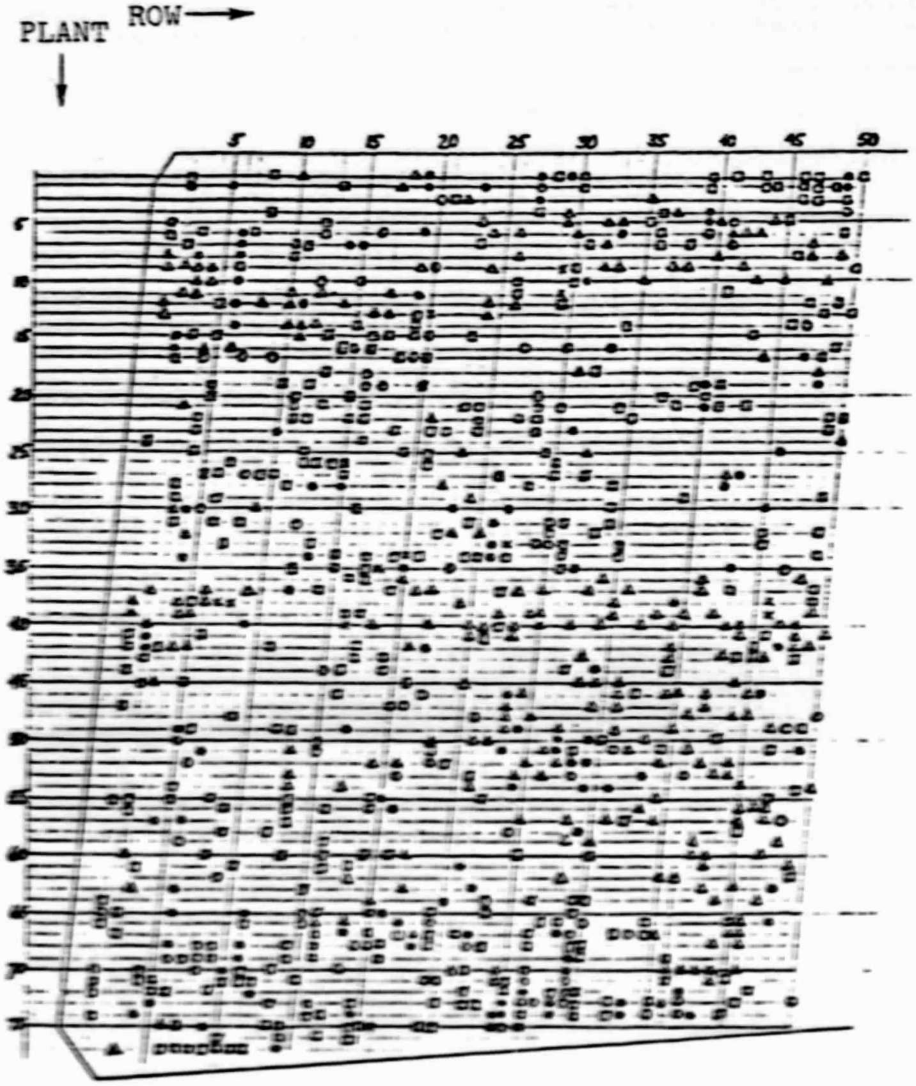
### Methods and Materials

At Cornell's request, NASA acquired color infrared aerial photographic coverage and 11-channel multispectral scanner data over vineyards along the western side of the southern portion of Keuka Lake, in New York State. The photographic and scanner data were acquired simultaneously at midday in June and August 1977; the thermal channel of the scanner was also operated during predawn hours on these two dates (Table 1).

As noted, the analysis focused on fields owned by the Taylor Wine Company, which furnished detailed information on the vines in each field (e.g., variety, age, spacing), and yield as determined by the average weight of bins of each variety collected from each field section.

For this preliminary study, 16 field sections, planted to three varieties of grapes were included; six sections were devoted to Concord, five to Catawba, and five to Delaware. The selection of the specific field sections was based on the number, homogeneity and age of the vines in the sections and the quality of the imagery.

Two plant morphological factors were considered: the continuity of the vine canopy in June and the width of the vine canopy in August. The average values of these quanti-




△ high vigor

□ low vigor

average vigor

○ very low vigor or gap

● gap or dead plant

X double plant

Figure 3. Airphoto interpreted vigor/health of vines in portion of first-year vineyard in Dresden area, N.Y. (See Fig. 4 for generalized assessment of entire field.)

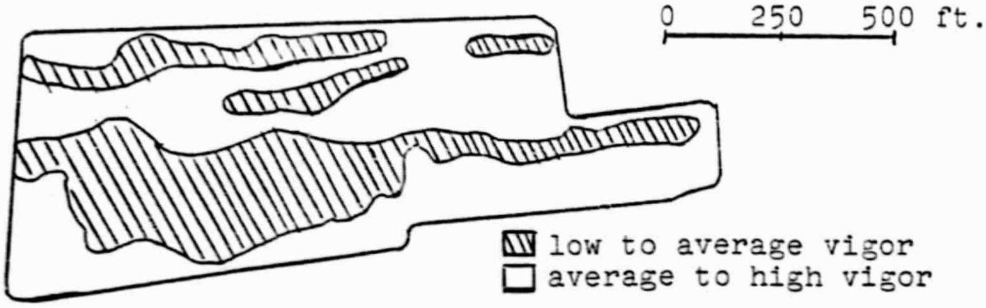



Figure 4. Airphoto interpreted vigor/health of vines in first-year vineyard in Dresden area, N.Y. (See Fig. 3 for detailed assessment of western portion of field.)

ties for each of the 16 field sections were determined photogrammetrically from the aerial photographs through a sampling process.

For crop spectral information, only the lower altitude scanner data were examined (ground resolution approx. 2.3-by-2.3 meters). In brief, the 16 field sections were located through refinement of computer printout brightness maps. The average radiance value (digital count, 0 to 255) in each spectral region (channels 1 to 11) was calculated for each section, and subsequently correlated with yield and related values for the section. Because the relative differences among sections were the principal quantities of interest, no attempt was made to calibrate the radiometric values or correct for atmospheric interactions.

## Results and Discussion

The results of this preliminary analysis are summarized in Table 2. Included are vine characteristics of the three varieties in the 16 field sections considered; correlation coefficients between the varieties' 1977 yields and the averaged radiometric responses from the sections, as sensed in 11 spectral regions, on two 1977 flight dates; and correlation coefficients between the varieties' 1977 yields and canopy continuity in June, canopy width in August, and the previous year's yields.

Three points are of importance in interpreting these results.

1. The number of field sections for any of the three varieties is too small to allow statistically valid statements.

2. The 1977 growing season followed a particularly harsh winter and late spring freeze which resulted in anomalously low yields (cf., 1976 yields, Table 2).

3. Yield values used in this analysis are based on average yields for the variety and may not be entirely accurate for the sections actually considered.

Even with these limitations, the results still provide a clear indication that further analysis is warranted. The

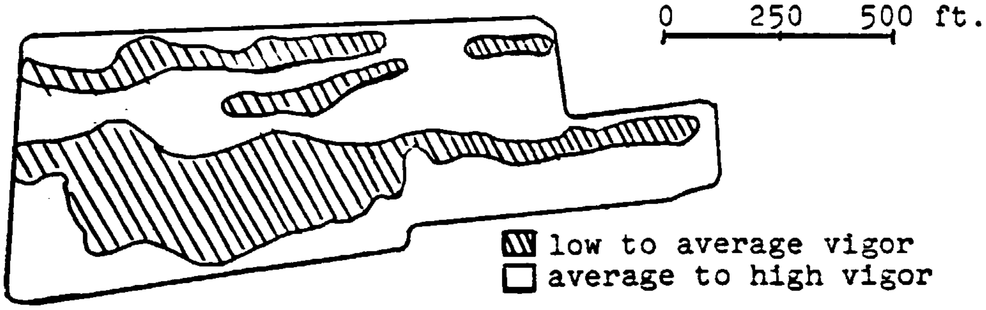



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Table 1. Remotely sensed data acquired for vineyard study.

| SENSOR | NATURE OF DATA | FORM OF DATA |
|---|---|---|
| metric camera; 9 in (23 cm) format, 6 in (15 cm) lens | color infrared film, 2443; 1:6,000 and 1:14,000 scales | duplicate positive transparencies |
| multispectral scanner; instantaneous field-of-view of 2.5 milliradians | scanner senses simultaneously in 11 channels (range in μm)<br>1) 0.411-.438<br>2) 0.449-.484<br>3) 0.490-.532<br>4) 0.532-.572<br>5) 0.572-.611<br>6) 0.612-.652<br>7) 0.653-.692<br>8) 0.692-.737<br>9) 0.762-.856<br>10) 0.953-1.031<br>11) 8.0-14.0 | visicorder prints of thermal channel; computer-compatible tapes of selected flight lines or parts of lines |

FLIGHT DATES: 22 June and 26 August 1977, midday (all data) and predawn (Channel 11 only).

FLIGHT ALTITUDES: nominally 3,000 and 7,000 ft above mean terrain (915 and 2,130 meters).

high correlations between yield and the August spectral responses for Concord are notable, as are several other correlations. The negative relationship between yield and most factors is of interest and cannot be fully explained.

As a final note, it is emphasized that multiple or nonlinear correlations (regressions) have not been examined, nor have relationships between yield and spectral or temporal ratios. Follow-up studies and possibly new aerial missions over closely monitored vineyards are being planned.

## CONCLUSIONS

As has been demonstrated, remote sensing can provide useful information for vineyard management, and in some cases at least, it can be provided in a cost effective manner. This is especially true of soil-related studies (e.g., drainage), which can normally make use of existing aerial photographs. With regard to vineyard crop monitoring, it would be relatively easy to develop a low cost scheme for periodically photographing vineyards with a small format camera from a light aircraft. Similarly, while investigations of yield estimation are more of a research endeavor, the results are encouraging and potentially transferrable to less expensive systems, including Landsat satellite data.

Table 2. Characteristics of test vineyards and correlations between yield and remotely sensed spectral and morphological factors.

| FACTOR | VARIETY DELAWARE | CONCORD | CATAWBA |
|---|---|---|---|
| No. Fields | 5 | 6 | 5 |
| Yield, tons/acre | | | |
| mean, 1977 (stan. dev.) | 1.31 (0.36) | 1.87 (0.37) | 3.52 (0.74) |
| mean, 1976 (stan. dev.) | 2.51 (1.01) | 5.09 (0.57) | 3.97 (1.39) |
| Vine Continuity, % | | | |
| mean, June 1977 (stan. dev.) | 80.9 (5.9) | 87.9 (2.4) | 84.5 (2.9) |
| Canopy Width, feet | | | |
| mean, Aug 1977 (stan. dev.) | 2.48 (0.77) | 4.05 (0.26) | 3.85 (0.39) |

| CORRELATED VARIABLES | r | | r | | r | |
|---|---|---|---|---|---|---|
| | JUNE | AUG | JUNE | AUG | JUNE | AUG |
| Yield, 1977 versus | | | | | | |
| Chan 1 | -.13 | -.79 | -.02 | -.90 | -.22 | -.47 |
| Chan 2 | -.13 | -.80 | -.02 | -.94 | -.25 | -.45 |
| Chan 3 | -.10 | -.79 | -.00 | -.96 | -.25 | -.45 |
| Chan 4 | -.06 | -.76 | .01 | -.96 | -.27 | -.49 |
| Chan 5 | -.10 | -.80 | .00 | -.96 | -.26 | -.41 |
| Chan 6 | -.11 | -.82 | .01 | -.96 | -.24 | -.33 |
| Chan 7 | -.11 | -.82 | .01 | -.95 | -.21 | -.33 |
| Chan 8 | .31 | -.71 | .07 | -.96 | -.18 | -.71 |
| Chan 9 | .79 | -.64 | .12 | -.95 | -.13 | -.85 |
| Chan 10 | .88 | -.67 | .12 | -.94 | -.11 | -.82 |
| Chan 11 | -.39 | -.98 | -.58 | -.65 | -.34 | -.11 |
| Continuity | .56 | | -.51 | | .30 | |
| Width | | .19 | | -.16 | | -.16 |
| Yield, 1976 | .99 | | -.81 | | .45 | |

ACKNOWLEDGMENTS

This study was supported by NASA Grant NGL 33-010-171, and conducted in cooperation with Mr. Harland W. Tyler, vineyards manager of Taylor Wine Co., Inc. Consultations were provided by Profs. Nelson J. Shaulis and Robert M. Pool, of the N.Y.S. Agricultural Experiment Station. Special acknowledgment is due Prof. Ta Liang, principal investigator of the Remote Sensing Program, for his advice and support throughout the vineyard studies.

# APPENDIX D

## Selected Correspondence

DONALD T. GLOO Chairman
Vice Chairman
MICHAEL GAPIN Program Director & Secretary

HERKIMER - ONEIDA COUNTIES COMPREHENSIVE PLANNING PROGRAM
ONEIDA COUNTY OFFICE BUILDING 800 PARK AVENUE UTICA, NEW YORK 13501 TEL. 315 798 5710

December 10, 1979

Warren R. Philipson
Senior Research Associate
Remote Sensing Program
School of Civil and Environmental Engineering
Hollister Hall
Ithaca, New York 14853

Dear Mr. Philipson:

Your correspondence of October 19, 1979 outlined interesting projects and research your program is involved with. I appreciate your solicitation of potential involvement with the Remote Sensing Program to address a problem in the Herkimer-Oneida Counties region.

This office has a long history of strong interest in improving the entire water supply, quality, and distribution systems for the residents of the region. In the past we have participated in and sponsored a wide range of water resource studies and plans. Our involvement includes planning related to maintenance of natural water resources, development of municipal water systems, and evaluation of water quality. In September of this year this office completed a Rural Water Supply Study. This inventory of 26 existing rural public water systems produced the identification of present and future system problems. In most cases we were able to offer potential general solutions to the problems identified. However, the nature of these solutions will, in most cases, require significant further study and analysis. For example, if a recommendation was to develop a new source of supply we do not presently have the capability to identify actual potential sources (i.e. well sites, surface water storage areas).

In a broader sense, this office has a committment to directing environmentally sound growth and development. Within this region there are several large public water systems, many rural public water systems that serve relatively small populations (less than 10,000), and large areas where individual households provide their own water service. In planning for the region's growth and development availability of a sufficient quantity and quality of water stands out as a key determinant. We have had to deal with a wide range of environmental, economic, social, and political concerns related to water resources in developing comprehensive growth policies and programs. These concerns and problems get progressively more complex each year. This, I think, is where your research capability can be of significant assistance to this region.

To adequately address the concerns and problems noted above, a reional analysis of potential ground water resources should be done. First, areas of significant potential for supply should be identified. Next, the associated areas that serve as recharge areas should be identified. The benefits of completing this research and analysis would be two fold. First, a community could for example, benefit directly through the identification of a potential well site. Second, from a regional perspective, this analysis would greatly improve the information available in developing policies and programs. It would certainly contribute to consideration of alternatives for solving water supply problems and possibly the protection of ground water resources and recharge areas through local land use controls.

In summary, I think it is very evident that a study through your program could greatly improve the Herkimer-Oneida Counties region's capability for dealing with water resource issues. I would be interested in meeting with you to discuss the potential for such work.

Thank you again for your interest.

Sincerely,

Michael Gapin
Commissioner

MG:HA:rm

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UNIVERSITÀ DI CATANIA
FACOLTÀ DI INGEGNERIA
ISTITUTO DI MACCHINE

95125 CATANIA, February 14, 1980
V.LE A. DORIA, 6 - TEL. (095) 330 240 - 330 258

Dr. Warren R. Philipson
Cornell University
Hollister Hall
Ithaca, New York 14853

Dear Dr. Philipson:

I am writing you according to the suggestions I had from Mr. Jhon J. Graham of Eastman Kodak Company of Rochester.

In connection with my academic activity at the University of Catania, I am involved in a research project on the use of remote sensing. The purpose of the project is to locate the areas where water bodies are being polluted by various kinds of industrial activity.

Enclosed you will find a copy of my interim report describing the work done to date on this subject. Any suggestion you may have to offer will be very appreciated.

Thank you for your cooperation in this matter.

Sincerely yours,

Alberto L. Geraci
Professor

ALG:cl
Encls.

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THE CATSKILL CENTER
for conservation and development, inc.

HOBART, NEW YORK 13788

Tel. 607 538-9117



February 19, 1980

Mr. Warren R. Philipson, associate professor
Cornell University
Remote Sensing Program
School of Civil and Environmental Engineering
Hollister Hall
Ithaca, New York 14853

Dear Mr. Philipson:

Receipt of your letter soliciting projects for the Remote Sensing Program was most timely. There are several projects here in the Catskills that The Center is involved with directly and indirectly that I think might interest you and that would directly benefit from aerial survey services.

The first is a forestry management program that is presently in the formative stage. This would be an initiative sponsored by The Catskill Center designed to provide professional forestry services within a conservation and "best resource use" framework to private landowners. Aerial surveying of the region's forestry resources, possibly utilizing infra-red techniques, could be of great assistance in targeting areas where management services would be most effective. Information on species distribution and canopy dimensions, if it could be extracted from the type of aerial photography you would use, could also be most helpful. The end product would be a readily utilized inventory of the Catskills' timber resources.

Another project that would benefit immediately by aerial survey is a proposed reuse of the Catskill Mountain Branch of the Penn Central Railroad. Ulster County has purchased the railroad within its border and is pursuing a project to develop the line as a tourist attraction. A similar railroad initiative for the remainder of the line west through Delaware County is in the formative stage, with a focus of rail service rather than just tourism. There is a very real need for a thorough land use analysis of the entire rail corridor -- from Kingston through Delaware County to a possible reconnection with the D&H Railroad at Oneonta. Survey data from Ulster County would be most helpful in the development of their project master plan, which is being coordinated by a professional consultant under joint

THE CATSKILL CENTER
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HOBART, NEW YORK 13788

Tel. 607 538-9117

February 19, 1980



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# REPLY MESSAGE

TO: [illegible]

[illegible] SMITH CONSTRUCTION CO., INC.
[illegible]
GREENEVILLE, TENN. 37743
[illegible]

SUBJECT: [illegible]

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SIGNED: [illegible]

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[illegible]

[illegible]

[illegible]

United States Department of Agriculture

Soil Conservation Service

771 Federal Building
100 So. Clinton Street
Syracuse, New York 13260

March [illegible], 1980

Mr. W. R. Philipson
Cornell University
Hollister Hall
Ithaca, New York 14853

Dear Mr. Philipson:

We are interested in learning more, in the Soil Conservation Service, about the applicability of LANDSAT imagery, in our soil survey procedures; specifically, we are interested in learning how we may use LANDSAT-C bands that have recorded thermal infrared radiation in our soil survey mapping activities in St. Lawrence County, New York.

Our soil mapping activities in the past have been on black and white, medium and high altitude photography. It is probable that we will continue to publish our soil surveys on this kind of a photo base. We do however, feel that there is potential for improving our soil survey techniques, by studying imagery from different sources, in order to see soil patterns before actual field checking takes place. If you can let us know the procedure to follow in securing some LANDSAT imagery, that we might evaluate its usefulness in soil mapping, I would appreciate it.

Sincerely yours,

Frederick L. Gilbert

Frederick L. Gilbert
State Soil Scientist

cc: [illegible], State Conserv., SCS, Syracuse, N.Y.
[illegible], Soil Scient., SCS, [illegible], N.Y.
[illegible], Soil Scient., SCS, Watertown, N.Y.

[illegible]

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SEMINAR IN REMOTE SENSING

List of Seminars

Spring Term 1980

| Date | Speaker | Topic |
|---|---|---|
| Jan [illegible] | Warren R. Philipson<br>Cornell University | Organizational Meeting—Overview of Seminars and Introduction to Remote Sensing |
| Jan [illegible] | Richard Sigman<br>Mathematical Statistician<br>U.S. Dept. of Agriculture<br>Washington, D.C. | Applications of Remote Sensing in Agricultural Sampling |
| Feb 4 | James R. Wray<br>Senior Geographer—Cartographer<br>U.S. Geological Survey<br>Reston, Virginia | Developments and Applications of Land Use and Land Cover Mapping from Remotely Sensed Data |
| Feb [illegible] | Ta Liang<br>Professor, Remote Sensing Program<br>Cornell University<br>Ithaca, New York | International Activities in Remote Sensing |
| Feb [illegible] | Walter [illegible]<br>Senior Research Scientist<br>NASA Langley Research Ctr.<br>Hampton, Virginia | Photographic Assessment of Water Quality Parameters |
| Feb [illegible] | Vivian Gornitz<br>Research Associate<br>Goddard Institute for Space Studies and Columbia University<br>New York, New York | Rock Type Discrimination Using 24-Channel Multispectral Scanner Data for Test Sites in Utah |
| Mar [illegible] | Robert A. [illegible]<br>Aerospace Engineer<br>NASA Lewis Research Center<br>Cleveland, Ohio | The Application of Aerial Thermography for Energy Conservation |
| Mar [illegible] | Alexander Malahoff<br>Chief Scientist [illegible]<br>National Ocean Survey, NOAA<br>Rockville, Maryland | Micro-Terrain of the Ocean Floor from [illegible] and [illegible] |

| Date | Speaker | Topic |
|---|---|---|
| Apr [illegible] | R. Keith Raney<br>Deputy Manager Technology<br>Canada Centre for Remote Sensing<br>Ottawa, Ontario, Canada | Introduction to Synthetic Aperture Radar |
| Apr [illegible] | James A. Hall<br>Advisory Engineer<br>Westinghouse Electric Corp.<br>Baltimore, Maryland | Array Sensors for the Visible and Near Infrared—Can They Compete with Scanners? |
| Apr [illegible] | John F. Lemmer<br>Staff Associate<br>Pattern Analysis and Recognition Corporation<br>Rome, New York | Remote Sensing Cultural Information from Panchromatic Imagery |
| Apr [illegible] | Howard L. Heydt<br>Manager, Digital Image Analysis Laboratory<br>General Electric Company<br>Beltsville, Maryland | General Electric's Digital Image Analysis Laboratory |
| [illegible] [illegible] | Karl-Heinz Szekielda<br>Remote Sensing<br>United Nations<br>New York, New York | Use of Remote Sensing in United Nations Programs |

| Date | Speaker | Title |
| --- | --- | --- |
| Apr [illegible] | [illegible] | Introduction to Synthetic Aperture Radar |
| Apr [illegible] | [illegible] | [illegible] |
| Apr [illegible] | [illegible] | [illegible] |
| Apr [illegible] | [illegible] | [illegible] |
| Apr [illegible] | [illegible] | [illegible] |

## CURRICULUM IN AERIAL PHOTOGRAPHIC STUDIES AND REMOTE SENSING, 1980-81

**A680 REMOTE SENSING: FUNDAMENTALS**
Fall. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor.
W. Philipson
Fundamentals of sensors and sensing in the electromagnetic spectrum. Coverage includes sensors; sensor and ground data acquisition; data geometry, analysis and interpretation; and mission planning.

**A683 REMOTE SENSING: ENVIRONMENTAL APPLICATIONS**
Spring. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor.
W. Philipson
Applications of remote sensing in various environmental disciplines. Emphasis is on the use of aircraft and satellite imagery for studying surface features in engineering, planning, agriculture and natural resource assessments.

**A685 PHYSICAL ENVIRONMENT EVALUATION**
Fall. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor.
T. Liang
Physical environment factors affecting engineering planning decisions: climate, soil and rock conditions, water resources. Evaluation methods: interpretation of meteorologic, topographic, geologic, and soil maps, airphotos, and subsurface exploration records.

**A687 IMAGE ANALYSIS I: LANDFORMS**
Fall. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor.
T. Liang
Analysis and interpretation of aerial photographs for a broad spectrum of soil, rock and drainage conditions. Specific fields of application are emphasized.

**A688 IMAGE ANALYSIS II: PHYSICAL ENVIRONMENTS**
Spring. 3 credits. 2 lec, 1 lab. Prerequisite: CEE A685 or A687.
T. Liang
Study of physical environments using aerial photographs and other remote sensing methods. Conventional photography, spectral, space and sequential photography; thermal and radar imageries. Arctic, tropic, arid, and humid climatic regions. Project applications.

**A691 PROJECT**
On demand. 1-6 credits.
Staff
Students may elect to undertake a project in remote sensing and environment evaluation. The work is supervised by a professor in this subject area.

**A692 RESEARCH**
On demand. 1-6 credits.
Staff
For students who wish to study one particular area in depth. The work may take the form of laboratory investigation, field study, theoretical analysis or development of design procedures.

**A694 SPECIAL TOPICS**
On demand. 1-6 credits.
Staff
Supervised study in small groups on one or more special topics not covered in the regular courses. Special topics may be of a theoretical or applied nature.

**A696 SEMINAR IN REMOTE SENSING**
Spring. 1 credit. S-U grades only.
W. Philipson
Presentation and discussion of current research, development and applications in remote sensing. Lectures by Cornell staff and invited specialists from government and industry.

CURRICULUM NOTES:

A680 *Remote Sensing: Fundamentals*, formerly A689 Remote Sensing, will be offered during the fall rather than during the spring semester. This course is still intended to provide a basic understanding of remote sensing. It is open to students of all disciplines.

A683 *Remote Sensing: Environmental Applications* is a new course, developed to complement the landform analysis course, A687. In the past, students who were interested in airphoto interpretation normally enrolled in A687. With the revised curriculum, many of these students whose major interest is in surface features would derive more from the new course, A683. This course is particularly useful for students in environmental engineering, natural resources, planning and landscape architecture.

A685 *Physical Environment Evaluation* is intended for students who wish to develop skills in integrating various data sources, including aerial photographs, for analyzing the physical environment. Although aimed at engineers, the course is of special value for geologists, planners and landscape architects.

A687 *Image Analysis I: Landforms*, formerly called "Analyses and Interpretation of Aerial Photographs," will be offered only during the fall semester. This course is intended to provide basic skills in using stereo black-and-white aerial photographs for interpreting engineering soil and geologic conditions. As such, it is of particular value for civil engineers, geologists and soil scientists.

A688 *Image Analysis II: Physical Environments*, will replace two former courses, Advanced Physical Environment Evaluation and Advanced Interpretation of Aerial Photographs. Intended as an extension of A685 and/or A687, the course should refine and expand the student's skills in visual image analysis of physical environments.

A697 *Project*, A692 *Research* and A694 *Special Topics* will remain in the curriculum and be available for students with some special interest which is not covered in the formal courses.

A696 *Seminar in Remote Sensing* will be offered only during the spring semester. This popular course has enjoyed large enrollments from students in many disciplines, and it will continue to be aimed at this audience.

# APPENDIX F

## Newsletter Recipients

[illegible]

[illegible]

[illegible][1]

1. [illegible]

[illegible]

2. [illegible]

3. [illegible]

4. [illegible]

[illegible]

5. [illegible]

| | |
|---|---|
| [illegible] | [illegible] |
| [illegible] | ([illegible]; Dir., Center for Envir. Research |
| [illegible] | [illegible] |

6. [illegible]

[illegible]

7. [illegible]

8. [illegible]

9. [illegible]

| | |
|---|---|
| [illegible] | ([illegible] Astronomy & Ionosphere Center; Prof.) |

[1] [illegible] office of each department [illegible] within the department. [illegible] provided to graduate and under- graduate students, upon request.

9. Astronomy (Cont.)

| | |
|---|---|
| C. Sagan | (Dir. Planetary Studies; Assoc. Dir. Radiophysics and Space Research; Prof.) |
| Y. Terzian | (Chairman; Prof.) |
| J. Veverka | (Assoc. Prof.) |

10. Atmospheric Sciences (Agronomy)

| | |
|---|---|
| B.E. Dethier | (Prof.) |
| W.W. Knapp | (Assoc. Prof.) |
| A.B. Pack | (Sr. Extension Assoc.) |

11. Biological Sciences

12. Boyce Thompson Institute

| | |
|---|---|
| E.H. Buckley | (Plant Biochemist) |
| J.B. Jacobsen | (Plant Physiologist) |

13. City and Regional Planning

| | |
|---|---|
| B. Saltzman | (Chairman; Prof.) |
| B.G. Jones | (Prof.) |

14. Civil and Environmental Engineering

| | |
|---|---|
| R.N. White | (Dir., School of C.E.E.; Prof., Structural Eng'g.) |
| D.A. Lyon | (Asst. Dir.; Assoc. Prof., Envir. Eng'g.) |
| J.F. Abel | (Assoc. Prof., Structural Eng'g.) |
| D.J. Belcher | (Prof. Emer.) |
| J.J. Bisogni | (Assoc. Prof., Envir. Eng'g.) |
| W.H. Brutsaert | (Prof., Envir. Eng'g.) |
| R.I. Dick | (Prof., Envir. Eng'g.) |
| L.B. Dworsky | (Prof., Envir. Eng'g.) |
| T.L. Eib | (Research Specialist, Remote Sensing Program) |
| D.F. Fisher | (Prof., Envir. Eng'g.) |
| C.D. Gates | (Prof., Envir. Eng'g.) |
| P. Gergely | (Prof., Structural Eng'g.) |
| J.M. Gossett | (Asst. Prof., Envir. Eng'g.) |
| R.E. Hollister | (Prof. Emer.) |
| A.R. Ingraffea | (Asst. Prof., Structural Eng'g.) |
| G.H. Jirka | (Asst. Prof., Envir. Eng'g.) |
| P.R. Jutro | (Sr. Research Assoc., Envir. Eng'g.) |
| F.H. Kulhawy | (Assoc. Prof., Structural Eng'g.) |
| T. Liang | (Prof., Remote Sensing Program) |
| J.A. Liggett | (Prof., Envir. Eng'g.) |
| P. Liu | (Assoc. Prof., Envir. Eng'g.) |
| D.P. Loucks | (Chairman, Envir. Eng'g.; Prof.) |
| W.R. Lynn | (Prof., Envir. Eng'g.) |
| W. McGuire | (Prof., Structural Eng'g.) |
| A.J. McNair | (Prof. Emer.) |
| A.H. Meyburg | (Prof., Envir. Eng'g.) |

14. Civil and Environmental Eng'g. (Cont.)

| | |
|---|---|
| A.H. Nilson | (Chairman, Structural Eng'g.; Prof.) |
| W. Brutsaert | (Assoc. Prof., Envir. Eng'g.) |
| T. Pekoz | (Assoc. Prof., Structural Eng'g.) |
| W.R. Philipson | (Assoc. Prof., Remote Sensing Program) |
| [illegible] | (Assoc. Prof., Envir. Eng'g. and Economics) |
| C.A. Shoemaker | (Assoc. Prof., Envir. Eng'g.) |
| F.O. Slate | (Prof., Structural Eng'g.) |
| J.R. Stedinger | (Asst. Prof., Envir. Eng'g.) |
| G. Winter | (Prof. Emer.) |
| [illegible] Yen | (Data Analyst, Remote Sensing Program) |

15. College of Agriculture and Life Sciences

| | |
|---|---|
| D.L. Call | (Dean) |

16. College of Architecture, Art and Planning

| | |
|---|---|
| K.C. Parsons | (Dean; Prof.) |
| W.W. Richardson | (Chairman; Assoc. Prof.) |

17. College of Engineering

| | |
|---|---|
| T.E. Everhart | (Dean) |
| P.R. McIsaac | (Assoc. Dean; Prof., Electrical Eng'g.) |

18. Computer Graphics

| | |
|---|---|
| D.P. Greenberg | (Dir.; Prof., Arch.) |

19. Computer Science

20. Design and Environmental Analysis

21. Ecology and Systematics

| | |
|---|---|
| J.P. Barlow | (Assoc. Prof., Oceanography) |
| G.E. Likens | (Prof. Ecology) |
| P.L. Marks | (Assoc. Prof., Biology) |

22. Education

23. Electrical Engineering

| | |
|---|---|
| R. Bolgiano, Jr. | (Prof.) |
| T. Fine | (Prof.) |
| W.H. Ku | (Prof.) |
| S. Linke | (Prof.) |
| C. Pottle | (Assoc. Prof.) |
| [illegible] | (Prof.) |

24. Entomology

25. Entomology Extension

26. Floriculture and Ornamental Horticulture

| | |
|---|---|
| M.I. Adleman | (Assoc. Prof., Landscape Architecture) |
| A.S. Lieberman | (Prof., Landscape Architecture) |
| P.J. Trowbridge | (Asst. Prof., Landscape Architecture) |

27. Geological Sciences

| | |
|---|---|
| J.E. Oliver | (Chairman; Prof.) |
| J.M. Bird | (Prof.) |
| A.L. Bloom | (Prof.) |
| A. Gibbs | (Asst. Prof.) |
| D.E. Karig | (Assoc. Prof.) |
| J. Ni | (Research Specialist) |
| W.B. Travers | (Assoc. Prof.) |

28. International Agriculture

| | |
|---|---|
| J.F. Metz | (Director; Prof., Marketing) |
| L.W. Zuidema | (Asst. Director) |

29. International Studies Center

30. Landscape Architecture Grad. Program

| | |
|---|---|
| L. Mirin | (Asst. Prof.) |

31. Materials Science and Engineering

32. Mechanical and Aerospace Engineering

33. Media Services

| | |
|---|---|
| S. Mosedale | (Science Newswriter) |

34. Military Science (Army R.O.T.C.)

35. Modern Languages and Linguistics

| | |
|---|---|
| E.J. Beukenkamp | (Dir. Eng./Modern Language Program) |

36. Natural Resources

| | |
|---|---|
| W.H. Everhart | (Chairman; Prof.) |
| H.B. Brumsted | (Assoc. Prof.) |
| J.W. Caslick | (Senior Research Assoc.) |
| L.S. Hamilton | (Prof.) |
| R.A. Malecki | (Asst. Prof.) |
| L. Mudrak | (Extension Assoc.) |
| R.T. Oglesby | (Prof.) |
| M.E. Richmond | (Assoc. Prof; Program Leader, Coop. Wildlife Research Unit) |
| B.T. Wilkins | (Assoc. Prof.; Program Leader, Sea Grant Advisory Service) |

37. Naval Science (Navy R.O.T.C.)

38. N.Y.S. Agricultural Experiment Station, Ithaca

T. Hullar (Assoc. Director)

39. Operations Research and Industrial Engineering

T.J. Santner (Asst. Prof.)
[illegible] (Prof.)
B.W. Turnbull (Assoc. Prof.)

40. Planning and Facilities

R.H. Eliason (Assoc. Dir. Energy Manag./Utilities)

41. Plant Pathology

S.V. Beer (Assoc. Prof.)
H.D. Thurston (Prof.)

42. Pomology

W.J. Kender (Chairman; Prof.)

43. Public Information

R.B. Stiles (Staff Writer)

44. Resource Information Laboratory

E.E. Hardy (Director)
E.H. Barnaba (Mgr. Technical Service)

45. Rural Sociology

H.R. Capener (Prof.)

46. Sociology

47. Sponsored Programs

T.R. Rogers (Director)

48. Theoretical and Applied Mechanics

49. Thermal Engineering

50. University Archives

G.F. Colman (Librarian)

51. U.S. Plant, Soil and Nutrition Laboratory

52. Vegetable Crops

## OFF-CAMPUS GROUPS AND INDIVIDUALS

Agency for Int'l. Development
Department of State
Washington, D.C.
(a) W.L. Eilers
(b) T.S. Gill
(c) C.K. Paul
(d) C. Withington

Alberta Remote Sensing Center
Edmonton, Alberta, Canada

Simon E. Ananaba
Department of Physics
Ahmadu Bello University
Zaria, Nigeria

Prof. James M. Anderson
University of California
Dept. of Civil Engineering
Berkeley, California

Dr. Richard W. Arnold
U.S. Dept. of Agriculture
Soil Conservation Service
Washington, D.C.

Prof. John W. Arnon
Memphis State University
Dept. of Geology
Memphis, Tennessee

Stan Aronoff
Dept. of Forestry
University of California
Berkeley, California

Pat Ashburn
USDA/FAS
Houston, Texas

Ing. Rafael J. Avila-F
Universidad del Zulia
Escuela de Geodesia
Maracaibo, Venezuela

Mark Baydon
New York State Energy Office
Albany, New York

Lew Baker
Bendix Aerospace Systems
Division
Ann Arbor, Michigan

Lawrence C. Baldwin
Centerville, Virginia

James C. Barnes
Environmental Research &
Technology, Inc.
Concord, Massachusetts

Dr. David J. Barr
Dept. Mining Petroleum Eng'g.
University of Missouri
Rolla, Missouri

Dr. Alan S. Barrett
Optronics International
Chelmsford, Massachusetts

Dr. A.R. Barringer
Barringer Research, Inc.
Golden, Colorado

Robert Batchelder
University of Calgary
Calgary, Canada

Thomas F. Baucom
Jacksonville State Univ.
Department of Geography
Jacksonville, Alabama

Frank Beatty
EROS Applications Assist.
Facility
National Space Tech. Lab.
NSTL Station, Mississippi

Gurdip S. Bedi
Embassy of India
Washington, D.C.

Dr. Klass Jan Beek
Int'l. Inst. for Land
Recl. & Improvement
Wageningen, The Netherlands

Jan P. Berger
Tams Engineers & Architects
New York, New York

Ralph Bernstein
IBM Corporation
Gaithersburg, Maryland

Dr. Joseph K. Berry
School of Forestry and
  Environmental Studies
Yale University
New Haven, Connecticut

J.L. Bessis
Centre Spatial de Toulouse
Toulouse, France

Dr. Jose F. Betancourt
Dept. of Geography
SUNY College
Brockport, New York

Colin Betts
Olds College
Olds, Alberta, Canada

Martha A. Blake
Department of the Army
Construction Eng'g. Research
  Laboratory
Champaign, Illinois

Milegos L. Bloom
Minneapolis, Minnesota

Dr. Lloyd R. Breslau
U.S. Coast Guard
Research & Development Ctr.
Groton, Connecticut

James Brogan
Niagara Mohawk Power Corp.
Syracuse, New York

Robert Brower
Cayuga Co. Planning Dept.
Auburn, New York

Walley W. Brown
Bethesda, Maryland

Ned Buchman
Public Technology
Washington, D.C.

Dr. Peter Burbridge
Ford Foundation
Jakarta, Indonesia

Calspan Corporation
Buffalo, New York
  (a) J.R. Schott
  (b) J.E. Walker

Canada Centre for Remote
  Sensing
Ottawa, Ontario, Canada
  (a) R.J. Brown
  (b) J. Cihlar
  (c) E.A. Godby
  (d) D.G. Goodenough
  (e) R.D. McGurrin
  (f) R.K. Haney
  (g) W.M. Strome

The Canadian Aeronautics &
  Space Institute
Ottawa, Ontario, Canada

Mr. Larry Carver
Map & Imagery Collections
  Library
University of California
Santa Barbara, California

Alvaro F. Castro
U.N. Development Programme
Maputo, Mozambique

Central Intelligence Agency
Washington, D.C.
  (a) J. Lynch
  (b) F.P. Rossomondo

Sherry Chou Chen
Institut Pesquisas Espacias
Sao Jose dos Campus, Brazil

Vern W. Cimmery
Bonneville Power Admin.
Portland, Oregon

Clark University
Graduate School of Geography
Worcester, Massachusetts

Jill Clayton
Geo. Abstracts, Ltd.
University of East Anglia
Norwich, England

Dr. Jerry C. Coiner
Dept. of Geology & Geog.
Hunter College
New York, New York

Dr. William Collins
School of Mines
Columbia University
New York, New York

Bernard J. Colner
U.S. Bureau of the Census
Washington, D.C.

Commonwealth Sci. & Indus.
  Research Organization
Deniliquin, Australia

Merrill Conitz
Regional Remote Sensing
  Facility
Nairobi, Kenya

Dr. Robert J. Conner
CIBA-GEIGY Corp.
Greensboro, North Carolina

James Cordes
Cordes and Company
West Redding, Connecticut

Robert Crowder
N.Y.S. Commerce Dept.
Albany, New York

Dr. Peter H. Crown
Dept. of Soil Science
University of Alberta
Edmonton, Canada

Prof. LeRoy A. Daugherty
Dept. of Agronomy
New Mexico State University
Las Cruces, New Mexico

Dr. Donald W. Davis
Nicholls State University
Dept. of Earth Sciences
Thibodaux, Louisiana

Antonio Martinez de Aragon
Instituto Geografico Nacional
Madrid, Spain

Lic. Daniel R. de La Puente
Coordinador Area Informatica
I.I.R.R.
La Rioja, Argentina

Defense Mapping Agency
St. Louis, Missouri
  (a) R.L. Kalum

Defense Mapping Agency
Washington, D.C.
  (a) J.C. Hammack

James A. Dobbin
Toronto, Ontario, Canada

Humberto G. dos Santos
SNLCS-EMBRAPA
Rio de Janeiro, Brazil

Art Dow
Gordon Head School
Victoria, BC, Canada

Dr. Wolfram U. Drewes
Central Projects Staff
World Bank
Washington, D.C.

Eastman Kodak Company
Rochester, New York
  (a) J.J. Graham
  (b) C.P. McCabe
  (c) M.R. Specht
  (d) K.N. Vizy

East-West Center
Honolulu, Hawaii
  (a) B. Currey
  (b) B. Koppel

Ecol. Impact Surveil.
  and Monitoring
Environ. Protection Serv.
Environment Canada
Ottawa, Ontario, Canada

Dr. A.J. Eggenberger
D'Appolonia Consulting
  Engineers, Inc.
Pittsburgh, Pennsylvania

Jan K. Eklund
AGA Corporation
Secausus, New Jersey

Curtis H. Elder
U.S. Bureau of Mines
Pittsburgh Mining & Safety
  Research Center
Pittsburgh, Pennsylvania

Environmental Remote
  Sensing Lab
Oregon State University
Corvallis, Oregon

ERIM
Ann Arbor, Michigan
  (a) D.S. Lowe
  (b) R.H. Rogers
  (c) T.W. Wagner

[illegible]

[illegible]

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[illegible]

[illegible]

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## [illegible]

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## [illegible]

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## [illegible]

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[illegible]

[illegible]

SELECTED ARTICLES

[illegible]

The Newsletter, a monthly report of activities and events in remote sensing, is sent to members of the Cornell community who have an interest in sensors and their applications.

## PRELIMINARY ANALYSIS OF VINEYARD YIELD

As a follow-up to earlier studies of vineyard diseases and vine vigor (Newsletter, March 1976 and March 1977), the staff of Cornell's Remote Sensing Program has begun to examine relationships between vine yield and those plant morphologic or spectral characteristics that can be assessed through remotely sensed data. It is believed that these relationships can provide useful information concerning vineyard management and, at least to some extent, be applicable in estimating yield.

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## [illegible]

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[illegible]

## [illegible]

[illegible]

[illegible]

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[illegible]

## CALL FOR POSTER SESSION PRESENTATIONS

A 3-day meeting, "Remote Sensing for Resource Management," will be held in Kansas City, Mo., 28-30 October 1980. Sponsored by the Soil Conservation Society of America, the conference will focus on the effective application of remote sensing to land and water resource problems, bringing together experts on applying remote sensing to resource management and persons engaged in managing North America's land and water resources. In addition to more than 50 invited speakers, a limited number of poster papers will be selected for presentation on 28 October. Persons interested in contributing to the poster session should submit a 200-word summary to Dr. Gary Johnson, c/o Applications Branch, EROS Data Center, Sioux Falls, South Dakota 57198, before 1 June 1980.

## Beach Inventory, continued

Various data sources were then considered and rated for obtaining the categorized beach information. These included aircraft photography and Landsat satellite data, as well as topographic maps, soil survey reports, meteorologic records, tax assessment records, hydrographic charts and field investigations. In general, it was shown that, while each data source is useful for deriving certain, specific types of information, most of the required information could or should be derived from aerial photographs. A systematic procedure was then recommended for using the available remotely sensed and supporting data to identify and characterize beach areas throughout the State's coastal zone.

The methodology will provide a critical element to the Coastal Zone Management Program being developed by New York's Department of State. In particular, the methodology will be incorporated into the planning process that identifies public shorefront areas appropriate for access or protection. The investigation was conducted by [illegible]

## [illegible]

[illegible]

The Newsletter, a monthly report of articles and events in remote sensing, is sent to members of the Cornell community who have an interest in sensors and their applications.

## EARTH RESOURCES SATELLITES - OUR EXPECTATIONS

by

Linda S. Dall

Dr. Dall, a senior geologist with Earth Satellite Corporation, received her M.S. and Ph.D. in Aerial Photographic Studies at Cornell in 1974 and 1976, respectively. The views expressed here are those of Dr. Dall and do not necessarily reflect the views or policy of the Cornell Remote Sensing Program.

It has been over seven years since the first earth resources satellite was launched. The future uses of the satellite data were as difficult to predict in 1972 as is the character of a newborn infant. Unfortunately, the over-optimistic and unrealized projections of the data from our "infant" Landsat, in the early years, led many users to feel that the system had been oversold. On the other hand, Landsat multispectral scanner (MSS) data have been applied to a number of uses beyond any of those originally predicted. Most major oil companies, for example, use Landsat imagery as standard procedure to obtain regional geologic information. Resource mapping programs have been conducted in many African countries where Landsat imagery has been a major data source, and photomaps containing cartographic coordinates are being constructed from mosaicked Landsat imagery. Crop area measurement and yield forecasting programs are utilizing Landsat. Although the satellite data received today are no different from those received in 1972, we now manipulate these data with sophisticated processing techniques, thus producing enhanced satellite imagery of vastly increased usability. (continued p. 11)

[illegible]

## AGU CALL FOR PAPERS

The Space Hydrology Committee of the American Geophysical Union is sponsoring sessions on Remote Sensing for Hydrology at the AGU Fall Meeting in San Francisco, 8-12 December 1980. Papers for oral or poster presentation are being solicited in all areas of research and application. Authors should forward four copies of an abstract, in AGU format, to Dr. Thomas J. Jackson, USDA Hydrology Lab., Rm. 139, Bldg. 007, BARC-West, Beltsville, Md. 20705, before 1 June 1980. For information, contact Dr. Jackson or the AGU, 2000 Florida Ave., N.W., Washington, D.C. 20009.

## Earth Resources Satellites, cont'd.

It is 1980, and we have passed from the infant to the child stage in earth resources satellite remote sensing. It is time to take another look forward and ask ourselves what we can expect, knowing that we may be again in error. The growth potential for the next group of earth-looking satellite systems and sensors is exciting. In this decade, we will see satellite sensors having higher resolutions, increased spectral responses, stereoscopic capabilities, all-weather capabilities, and all of this with more frequent coverage.

Landsat-D, to be launched in 1982, will carry a Thematic Mapper, which will provide imagery with better than a twofold improvement in spatial resolution over the current MSS in six spectral channels, and also a 120 meter resolution thermal channel. These added channels will improve lithologic discrimination for geology, especially channels 1, 5, and 7 (0.45-0.52μm, 1.55-1.75μm, and 2.08-2.35μm, respectively). Also, the shorter wavelength channel (0.45-0.52μm) has a better water penetration capability than any of the MSS bands, thus aiding the mapping of submarine topography. The better resolution thermal channel will improve geothermal area identification and the mapping of thermal inertia.

Stereoscopic capability will be provided in 1984 by the French satellite SPOT (Systeme Probatoire d'Observation de la Terre) and perhaps by the United States' Stereosat. Sensors on these satellites will have spatial resolutions of up to 10 meters. Digital terrain mapping (topographic) will be possible with data received from these satellites.

NOSS (National Ocean Survey System) is a two-satellite system designed primarily for ocean work, but as a side benefit from its synthetic aperture radar (SAR), NOSS has the potential to image land surfaces (as did Seasat). Further into the future, GEOSAR has been given high priority in the U.S. space budget, and it would also carry a SAR system. All-weather radar mapping of the U.S., for example, could be accomplished in about four hours with better than 100 meter resolution.

Advances in atmospheric modeling in the 1980s should permit the development of absolute signatures of materials, with corresponding increases in reliability in the interpretation of crop and other surface types and classes.

Perhaps the most significant event influencing the 1980s is not technical. On November 26, 1979, President Carter announced that the experimental U.S. remote sensing program would go operational, with responsibility assigned to NOAA. The resulting guarantee of continued and reliable satellite data may have more important effects on the practical uses of Landsat data than any one technical breakthrough.

## SELECTED ARTICLE

Keene, K.M. and C.D. Conley. 1980. Measurement of irrigated acreage in western Kansas from Landsat images. Environ. Geol. 3:107-116.

The Newsletter is made possible by a grant from the National Aeronautics and Space Administration to Cornell's School of Civil and Environmental Engineering. Address comments to Dr. W.R. Philipson, Cornell University, Hollister Hall, Ithaca, N.Y. 14853 (tel. 607-256-4330)

The Newsletter, a monthly report of articles and events in remote sensing, is sent to members of the Cornell community who have an interest in sensors and their applications.

## CORNELL CURRICULUM CHANGES

Aerial Photographic Studies and Remote Sensing courses that will be offered during 1980-81 by Cornell's School of Civil and Environmental Engineering include [FALL SEMESTER] Remote Sensing--Fundamentals (A680), Physical Environment Evaluation (A685), and Image Analysis I--Landforms (A687); [SPRING SEMESTER] Remote Sensing--Environmental Applications (A683) and Image Analysis II--Physical Environments (A688). All are 3-credit hour courses, with two 50-minute lectures and one 2-hour laboratory each week (14 weeks).

In addition, the Seminar in Remote Sensing (A696, 1 credit hr) will be offered during the spring semester, and three other courses, Project (A691), Research (A692), and Special Topics (A694), will be offered on demand during either semester. These latter three courses are designed for individual or small group instruction, and may receive from 1 to 6 credit hours. Recent Special Topics courses have focused on digital analysis of remotely sensed data, soils of the tropics, and arid environments. For further information, contact Profs. Ta Liang or Warren Philipson, in Hollister Hall.

## REMOTE SENSING INDUSTRY DIRECTORY

Public Technology, Inc., a not-for-profit, public interest, science and technology transfer organization, is working with NASA's Regional Remote Sensing Applications Transfer Program to compile a directory of U.S. remote sensing firms. This directory will be published as part of a set of remote sensing procurement guidebooks aimed at assisting state and local governments to more effectively utilize the private sector for remote sensing products, services and equipment. The guidebooks and industry directory will be available in the Fall, 1980. Organizations wishing to be included in the "Remote Sensing Industry Directory" should request a directory questionnaire from Public Technology, Inc., 1140 Connecticut Avenue, N.W., Washington, D.C. 20036. Att'n. Ned Buchman.

## SUMMER COURSES/WORKSHOPS

3rd Annual Geographic Information Analysis Workshop; 3 & 4 June; $150; Contact: Yale Univ. School of Forestry & Environmental Studies, 205 Prospect St., New Haven, Conn. 06511. (tel. 203-436-0440).

3rd Annual Vegetation Remote Sensing Workshop; 15-20 June; $385 until 16 May, $425 thereafter; Contact: Remote Sensing Lab., School of Natural Resources, Univ. of Michigan, Ann Arbor, Mich. 48109.

Infrared Technology--Fundamentals & System Application; 16-20 June, $450; Contact: Engineering Summer Conferences, 400 Chrysler Center, North Campus, Univ. of Michigan, Ann Arbor, Mich. 48109.

Advanced Infrared Technology; 23-27 June; $450; Contact: see Infrared Tech. course listed above (total fee for both courses, $750).

Microwave Sensing Technology with Emphasis on Synthetic Aperture Radar Systems; 23-27 June; $475; Contact: see Infrared Tech. course listed above.

Terrain Analysis--Interpretation of Aerial Photographs & Images; 23-27 June; $495; in Sioux Falls, S.D.; Contact: Continuing Education Program, Harvard Graduate School of Design, Gund Hall L-37, Cambridge, Mass. 02138 (tel. 617-495-2578).

## SUMMER VACATION/ADDRESS CHANGES

Volume VIII of the Cornell Remote Sensing Newsletter ends with this May issue. The Newsletter is currently received by more than 500 individuals and groups in 40 states and 20 countries. As planned, Volume IX of the Newsletter will begin next September. Notices of address changes should be sent to the Remote Sensing Program (see bottom, p2).

LeMaster, E.W., J.E. Chance & C.L. Wiegand. 1980. A seasonal verification of the Suits reflectance model for wheat. Photogram. Eng'g. & Remote Sensing 46:1:107-114.

Sangrey, D.A. and W.R. Philipson. 1979. Detecting landfill leachate contamination using remote sensors. EPA-600/4-79-060. U.S. EPA, Las Vegas, Nevada. 67pp.

Proc. of 4th Pecora Symposium, "Application of Remote Sensing Data to Wildlife Management." Held Sioux Falls, S.D., Oct. 1978. 397 pp. Avail.: National Wildlife Federation, 1412 16th St., N.W., Washington, D.C. 20036. ($10).

Proc. 7th Biennial Workshop on Color Aerial Photography in the Plant Sciences & Related Fields. 255 pp. Held Davis, Calif., May 1979. Avail: Amer. Soc. Photogrammetry, 105 N. Virginia Ave., Falls Church, Va. 22046. ($15 members/$19.50 non-members).

Proc. "Thermosense I," 1st Nat'l. Conf. on Capabilities & Limitations of Thermal Infrared Sensing Technology in Energy Conservation Programs. 217 pp. Held Chattanooga, Tenn., Sept. 1978. Avail: Amer. Soc. Photogrammetry (see above) $10 members/$15 non-members.

Photogram. Eng'g. & Remote Sensing 1980. v.46, n.2 (Feb)

-Martin, S.E. Color image maps from black-and-white photographs.

-Welch & Zupko. Urbanized area energy utilization patterns from DMSP data.

Shimabukuro et al. Automatic classification of reforested pine and eucalyptus using Landsat data.

-Millard et al. Experimental relations between airborne and ground measured wheat canopy temperatures.

-Iranpanah & Esfandiari. Interpretation of structural lineaments using Landsat-1 images.

-Honey, F.R. Modifications to Interpretoskop optics for stereo viewing of 70mm aerial photography.

Remote Sensing of Environment 1980. v.9, n.1

-Welch, R. Monitoring urban population and energy utilization patterns from satellite data.

-Walsh, S.J. Coniferous tree species mapping using Landsat data.

-Soer, G.J.R. Estimation of regional evapotranspiration and soil moisture conditions using remotely sensed crop surface temperatures.

-Loffler & Margules. Wombats detected from space.

-Stowe & Fleming. The error in satellite retrieved temperature profiles due to the effects of atmospheric aerosol particles.

-Beer, T. Microwave sensing from satellites.

-Idso et al. Estimation of grain yields by remote sensing of crop senescence rates.

Remote Sensing of Environment 1980. v.9, n.2

-Sweet et al. Vegetation of central Florida's east coast...

-Dugan, J.P. Characteristics of surface temperature structure and subsurface mesoscale features.

-Otterman et al. Atmospheric effects on radiometric imaging from satellites under low optical thickness conditions.

-Vickery et al. Assessment of the fertilizer requirement of improved pasture from remote sensing information.

-Schaber et al. Remote sensing data of SP Mountain and SP lave flow in north-central Arizona.

-Elachi & Farr. Observation of the Grand Canyon wall structure with an airborne imaging radar.

-Tucker, C.J. A spectral method for determining the percentage of green herbage material in clipped samples.

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